SCIENTIFIC AMERICAN
No. SUPPLEMENT 667

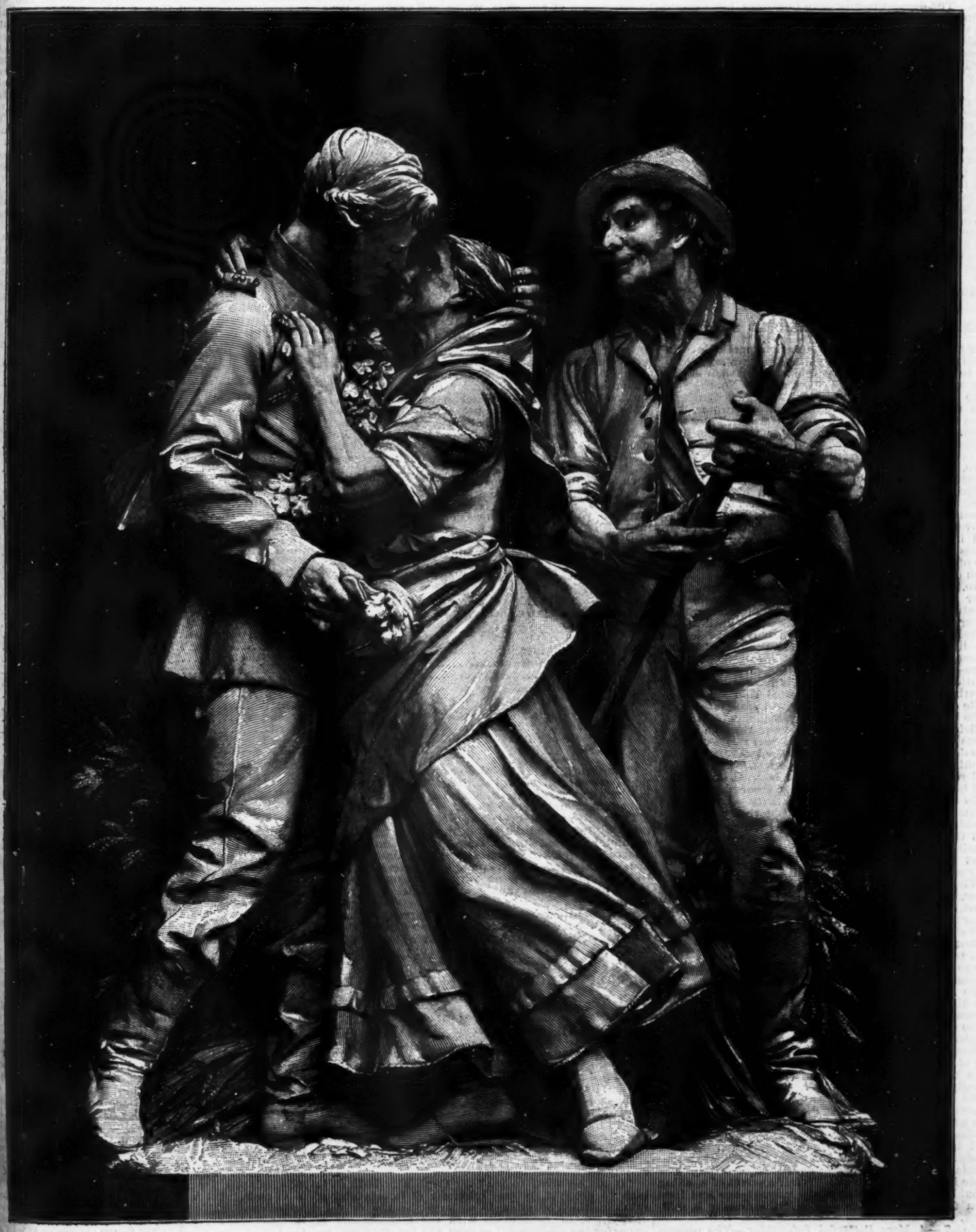
Scientific American Supplement, Vol. XXVI, No. 667.
Scientific American, established 1845.

NEW YORK, OCTOBER 13, 1888.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE SOLDIER'S RETURN.—BY ROBERT DIEZ.

REALISM certainly is appropriate and suitable in a monument commemorative of war and victory, if anywhere. Our army is the people in arms, and if the deeds of the army are to be celebrated, the people have a right to demand an intelligible and touching expression of their feeling. Allegories and symbols leave the heart cold, although they may move the understanding of the educated class. In Diez' group, "The Warrior's Return" (at the International Jubilee Art Exhibition, in Munich), we see an example of popular and at the



THE SOLDIER'S RETURN.—BY ROBERT DIEZ.

same time technically perfect art. It is a part of the war monument at Braunschweig, which consists principally of a triumphant Germania. The pedestal bears war scenes on two sides, on the third are life size figures of three Braunschweig soldiers, and on the fourth, our group. The last is the work of Robert Diez, of Dresden, from his own sketch, while the rest of the monument was, for the most part, designed by Breimann, who died in Dresden in 1878, before he had been able to complete his work. Breimann had thought originally of two ideal figures representing Victory and History as ornaments for the fourth side; but after his death the committee intrusted the completion of the monument to Diez.

The artist executed his task in the best possible manner. The work scarcely needs explanation. The soldier has just returned to his home. He found no one in the house, and, impatient to greet his dear ones, he hurried out to the field, where he surprised the old parents, who were busy with the harvest. The first meeting was among the sheaves. The mother has dropped all that she held in her hands and thrown herself on the breast of her dear son. Happiness beams from her eyes, for she is holding her son safe in her arms again after he has passed through so many dangers. The deepest mother-love brightens her peasant features. All her anxiety and tears are forgotten in the one thought, "I have him again." The son's feeling is also beautifully expressed. He has respectfully removed his laurel-trimmed cap and bends lovingly toward the true mother. The old father stands thoughtfully at one side. He still holds the scythe which he has just used, and, with half open mouth, he watches the greeting between mother and son, waiting patiently until the outburst of motherly love shall allow him his right.

This group, in connection with the other parts of the monument, is certainly appropriate. There is nothing to explain, and nothing to surmise; Germany's glory and Germany's prosperity are expressed; German love and feeling speak through these figures. The entirely characteristic representation of the figures contributes much to the effect of the work. They are real types, full of life, strength, and truth. Robert Diez now stands alone in Dresden as a representative of intelligent realism in the plastic art. The work on which his fame is founded, and which received the first medal in all the large exhibitions, is the "Gänsedieb" fountain at Dresden. In later years he has worked on two beautiful monumental fountains.—*Illustrirte Zeitung.*

INTENSIFICATION—WEAK AND STRONG.

IN the following paragraphs, various methods of intensifying gelatino-bromide plates are arranged according to the amount of density producible by their means. The weakest is called No. 1, the strongest No. 8.

No. 1.—*Almost Imperceptible Increase of Density.*—The negative is soaked for a minute in water, then dried rapidly by taking off the surface moisture with a soft cloth or blotting paper, after which the plate is placed in a horizontal position and exposed to a current of warm, dry air, until it is quite dry.

No. 2.—*Perceptible Increase of Density.*—The wet negative is wiped back and front with a cloth, then immersed for a few minutes in a bath of methylated spirits; when taken out it is drained for a few seconds, wiped again with a dry cloth, and held before the fire or over a gas flame, keeping it at a safe distance at first, and in a horizontal position. Should any opalescent stains appear, they can easily be removed by rewetting the plate, and drying without heat, after the use of the bath of spirits.

No. 3.—*Slight Increase of Density.*—The plate, after being washed from the hypo, is immersed in a saturated solution of bichloride of mercury in water. It should remain in this bath until it becomes white; if it refuses to bleach, it is probable that the hyposulphite has not been all removed. The bleached plate is rinsed for about three seconds—not more—in water, so as to remove the surplus mercury solution from the surface, then it is at once dipped into a bath consisting of a semi-saturated solution of sulphite of soda. This second bath will slowly turn the plate black, and will also, as a consequence of the insufficient washing, cover the surface of the film with a dense white deposit, which cannot be rubbed off; but this deposit will very quickly dissolve away in the final washing and leave the image perfect. The density will remain the same if the plate is dried slowly, but will be increased by drying quickly, according to No. 2.

No. 4.—*Moderate Increase of Density.*—The plate is treated precisely as in No. 3, except that a thorough washing is given between the bichloride of mercury and the sulphite of soda baths. This gives additional density. No white deposit will be produced, but a good final washing should be given. Extra density may also be produced by quick drying.

When the image is of a deep yellow or non-actinic color, such as is sometimes produced with pyro development, the use of this intensifier, No. 4, will alter the color to a neutral gray of about equal printing value. If it should then prove to be too dense, the plate can be immersed for a few minutes in the hypo bath. This will take away the extra density, and leave a gray image equal in depth to the original yellow one, but of course much quicker for printing purposes.

No. 5.—*A Vigorous Intensifier.*—The plate, or rather the film upon it, is bleached in a saturated solution of mercury bichloride in water, washed, dried; then, *when dry*, immersed in a semi-saturated solution of sulphite of soda, washed again, and dried. The only difference between this process and No. 4 is in the drying of the plate between the mercury and sulphite of soda baths. This drying causes a decided increase of density.

No. 6.—*A Powerful Intensifier.*—This, the well-known ammonia process, is about equal in strength to the preceding. The plate is bleached as before, and washed *thoroughly*. If the washing is too short, stains will be produced which cannot be removed. After washing, the wet plate is immersed in very weak ammonia (water, twenty parts; ammonia, one part). The plate instantly turns black. A fair amount of washing should be then given to secure permanence and freedom from stains. Dry slowly, if the density is sufficient.

No. 7.—*A More Powerful Intensifier.*—The process is the same as No. 6, but the ammonia solution may be used weaker, and the plate immersed in it for a longer period. The drying should also be rapid, as in No. 2.

No. 8.—*A Very Powerful Intensifier.*—It is very rarely that negatives are so weak that No. 7 is insufficient to bring them to a robust condition; however, by accident, a mere skeleton of an image, a ghost of a negative, is sometimes produced, which may be perfect in detail, but is hopelessly deficient in density. With such negatives the following process—hitherto unpublished, so far as the writer knows—may be used as a "forlorn hope." It produces an increase of vigor about twice as great as No. 7, although the treatment is almost the same. It is needless to say that this method is altogether too powerful for ordinary cases of intensification, but when a really strong treatment is necessary it is invaluable. The negative is bleached in a saturated solution of mercury bichloride, *well* washed, and then dried. It need not be "bone" dry. The gelatine should contain a small residuum of moisture, as if it had been in a damp place. A shallow tray is then selected a size smaller than the glass; thus a quarter-plate tray may be used with a half-plate negative. This tray is half filled with strong ammonia, and the dry bleached plate placed, film side downward, on the dish as if it were a lid. The film will be thus exposed to the fumes of ammonia, which will gradually penetrate and turn the image to a dark brown or black color. After ten minutes or so, the plate may be removed, reared up to dry for half an hour without washing, and then varnished.

TO CURE OVER-INTENSIFICATION.

There is a very simple method of reducing negatives which have been intensified by mercury solutions. It is simply to leave them in the fixing bath for a longer or shorter period, according to the amount of reduction desired. If left for half an hour, the whole of the extra density imparted by the intensifying process will be removed, and the plate will then be in its original condition. The hypo should of course be finally freed from the film by a copious washing.

STAINS.

These are never produced with the sulphite of soda method, even when the intermediate washing is very short, as in No. 3. Stains are, however, liable to appear with the ammonia system, if the washings are not thorough. Hence with No. 6 and No. 7 special attention should be given to this point, both before and after the use of the ammonia bath.

LOCAL INTENSIFICATION.

It frequently happens that intensification is desirable in some parts of a negative which in other parts is already sufficiently dense. In such a case the negative should be thoroughly wetted, then placed in a horizontal position, and the bichloride of mercury solution applied with a large, soft camel hair brush. The previous wetting will tend to prevent harsh edges being formed around the intensified parts. After washing, if a *slight* increase of density is wanted, the sulphite of soda solution is applied; if a greater degree of vigor is desired than this will give, a weak ammonia may be used instead, either alone or mixed with the sulphite bath, according to the density desired.

In the case of a negative which has had a part only of its surface bleached, it is essential to use a copious supply of running water to wash away the mercury solution. If the plate were merely placed to soak in a dish of water, the mercury contained in the gelatine would soon be diffused throughout the water, and by reacting on the film would cause a general bleaching of the whole surface.—*Albert Wm. Scott, in Br. Jour. of Photo.*

In addition to the above, we recommend Monckhoven's cyanide of silver intensifier, made as follows:

No. 1.

Bichloride of mercury	120	gr.
Bromide of potassium	60	gr.
Water	12½	oz.

No. 2.

Cyanide of potassium crystals (pure)	120	gr.
A. Water	6¼	oz.
B. Nitrate of silver	120	gr.
Water	6¼	oz.

Pour A into B, which forms cyanide of silver. A slight excess of silver will settle at the bottom of the bottle, which assists in keeping the solution up to its full strength and does no harm.

The plate should be left in No. 1 until the film appears white on the back. It is then thoroughly washed and immersed in No. 2, or the solution may be poured on quickly. Immediately the film will commence to blacken, and the plate should be kept in until there appears to be no white color on the back. If left too long, the cyanide will commence to reduce the negative.

This intensifier acts rapidly and imparts to the film a bluish black color. It is an excellent intensifier for lantern slides, imparting a desirable warm purple color.

PULP MANUFACTURE FROM WOOD IN GERMANY.

THE *Paper Makers' Circular*, of London, prints the following report of the agent of the Canadian government in Germany:

"The accompanying are samples of a new fiber material which is now prepared in enormous quantities, and is bound to have an immense influence on the paper making industry. There are factories which turn out as much as fifty tons of it a day.

"The invention was covered by a patent until recently, and the inventor has made a large fortune out of royalties. The imperial law courts have now caused the patent rights to be canceled, as the process appears to have been revealed to Professor Mitscherlich by a Scotchman.

"It has occurred to me that Canada is destined to turn to account its vast resources of forests and of sulphur, which latter exists so largely in the deposits of pyrites, in connection with the manufacture of paper for the continental or even the international requirements.

"If our existing supply of wood were to be devoted to the paper industry, it would soon be exhausted, and prices would rise very much.

"With the profits to be derived from Canada's forest resources in this direction, the railway debt could easily be paid off, and settlers, instead of burning the pine and fir, might obtain a substantial return for that which they are compelled to destroy.

"If the idea I have thrown out should meet with any support in Canada, I should be prepared, with my friend, to arrange for the promotion of a company in Germany for the utilization in a large way of Canadian wood fiber.

"At the Universal Exhibition, in Paris, 1867, the firm of Mr. Volter in Heidenheim (Wurtemburg) exhibited for the first time a new sort of paper pulp, prepared of pine wood. This pulp had been ground by means of iron or steel rollers. On account of its cheapness, in comparison to pulp from rags, this pine wood pulp was very easily sold. But it was only fit for the inferior sorts of paper, for the fibers became too short by this process of grinding them, and the paper afforded too little firmness and tenacity. Eight years ago Professor Mitscherlich discovered a chemical process for manufacturing the wood fiber by solving the wood in sulphuric acid and thus making so-called cellulose (lignine). For this process he took out a patent in Germany and other countries, but, by the legal verdict of the supreme court of justice in Germany, this patent was canceled, because before the conferring of this patent the process had already been published in a scientific paper. Thus the manufacture of cellulose is now free in Germany. Mitscherlich demanded from each manufacturer a license of 10,000 marks, and then two marks each 100 kilogrammes of the produce. This license is now annuled. In the meanwhile the cellulose has replaced almost all the other substitutes in the paper industry, and there is no doubt that this process will continue in still larger proportions. The use of cellulose has no limits at all, and depends only on the conditions that we can dispose of a sufficient quantity of the pine wood, of water for washing the cellulose, and of the opportunity to conduct the waste water into the rivers. These two conditions are not easily to be had in Germany, for lately the cellulose factories are classed among the burdensome establishments, and by this their erection is aggravated and its cost enhanced. According to the 'Annuaire de la Papeterie Universelle de 1886' (General Annals of the Paper Trade), the different countries have the following numbers of paper mills and machines:

Possessed by—	Paper Mills.	Machines.	Tubs or Chst.
France	420	525	.....
Great Britain—			
England	280	430	
Scotland	68	98	361 541 .....
Ireland	13	13	
Belgium	30	48	.....
Denmark	10	10	.....
Spain	72	47	140
Portugal	16	7	.....
Greece	1	1	.....
Holland	61	40	80
Italy	228	158	300
Russia	133	137	.....
Sweden	48	26	.....
Norway	8	8	.....
Roumania	3	3	.....
India	6	4	.....
Japan	6	6	.....
Syria	1	.....	.....
Island of Mauritius	1	.....	.....
Egypt	1	.....	.....
Australia	4	6	.....
New Zealand	2	1	.....
Canada	36	44	.....
Mexico	11	12	.....
Cuba	1	2	.....
Argentine	3	3	.....
Brazil	5	4	.....
Venezuela	1	1	.....
United States of America	884	1,106	.....
Further, according to the Address Book of Gnutter Staib Biberach, XI. edition, 1886—			
Germany	809	891	.....
Austria-Hungary	220	273	.....
Switzerland	35	46	.....
Luxemburg	2	2	.....
Total sum	3,419	3,952	520

"Supposing now each of these 3,952 machines has a daily production of only two tons, we obtain a yearly consumption of pulp amounting to at least 2×3,952×300=2,371,200 tons, or nearly 2,400,000 tons a year. Where now to get the raw materials for such an immense produce of paper? Here the thought swerves involuntarily over to Canada. In its abundance of vast pine woods and clear water, the discharge of which is in our country objected to, Canada alone has the possibility of meeting the wants of the world for this new branch of industry. Suppose the yearly produce of paper to amount to 2,400,000 tons, and half of this weight, say 1,200,000 tons, to be made of wood pulp, and, further, that each ton of finished paper requires three tons of wood pulp, then the total consumption of paper demands 3,600,000 tons of pine wood. But Canada furnishes besides the wood still other important additional materials for the manufacture; for instance, coal for firing and common iron pyrites for distilling the sulphuric acid. Canada possesses all these raw materials in the vicinity of its shipping ports. The freight from Canada to Europe can, therefore, not come into consideration against these enormous advantages. But till now a great part of the wood adapted for paper manufacture is simply burned in Canada. Let us suppose that Canada is able to furnish only half of these 3,600,000 of tons, say about 1,800,000 tons every year, and let us further calculate the ton of pine wood at 100 to 120 marks, as it will cost in Germany, we obtain for Canada a gross receipt of

198,000,000 marks, from which the freight expenses are to be deducted. But even these expenses remain again in Canada for the benefit of either its inland economy or of its equipment. The author thinks it his urgent duty to call the attention of the government to this favorable opportunity of so immensely increasing the receipts as well of the government, which has the sole right on all the wood on its land, as of private persons. The writer now proposes that your government should take this matter in hand and make arrangements for the manufacture of pine wood pulp, whereby Canada may also retain the profits from this work.

"The European production suffers everywhere from two facts: 1. From the high prices of wood, which will more and more increase in consequence of this industry. 2. From the difficulties of establishment, the necessary water not being at disposal, neither in sufficient quantity nor clearness, and, finally, what is worst of all, that no favorable discharge is to be had, because the drainage of the waste water into the rivers is not permitted on account of the fishing, water works, and so on. I submit now to your government samples of (1) bleached pulp, (2) of raw paper pulp, (3) of raw paper pulp bleached and dried. The latter costs 40 marks per 100 kilogrammes. By personal observation made with one of the first engineers in the German paper trade, I am willing and able to give the necessary instruction for the establishment of cellulose manufacture, and also to make arrangements for the sale of the finished pulp in Europe, and I am waiting for corresponding directions. Just now I read in the weekly paper of Gnutter Staib from the *Weekly Review:* 'The Vistula brought from Germany 1,600 bales of German cellulose to Leith. The value of this cargo amounts to £2,500.'

"The utilization of the material increases every day, and the price per hundredweight is now about 15 marks. Imagine the number of hundredweights that Canada's forests would furnish. If war does not break out in the meantime, I shall send my son to Canada in course of the present year to investigate the matter more thoroughly."

THE VALUE OF OIL AS FUEL.

IN the course of a lecture delivered by Dr. Charles B. Dudley before the Franklin Institute, he made a comparison between the fuel values of petroleum and of different varieties of coal. For this purpose the composition of the oil was assumed to be 85 per cent. of carbon (by weight) and 14 per cent. of hydrogen. Anthracite coal was supposed to contain 90 per cent. of carbon; and bituminous coal was credited with containing 85 per cent. of carbon and 5 per cent. of hydrogen. Calculated upon this basis, 1 lb. of the oil was shown to be theoretically equal to 1·61 lb. of the anthracite and to 1·37 lb. of the bituminous coal. Mr. Urquhart compares oil with coal as 1 to 1·756; and this valuation is confirmed by experiments at Detroit and upon the New York elevated railroad, all of which go to show that in round numbers 1 lb. of oil is capable of doing the work in the boiler furnace of 1¾ lb. of the very best coal. Considering that oil is generally bought by the gallon or barrel, and coal by the ton—which, however, he takes at only 2,000 lb.—Dr. Dudley publishes in the *Journal of the Franklin Institute* some tables in which the relative values of the two kinds of fuel are balanced, both with reference to fuel account alone and also taking all ascertained economies into the computation. Upon the simple fuel basis, it appears that oil costing $1 per barrel of 42 gallons is equal in value to coal at $3.73 per ton of 2,000 lb. With all ascertained economies considered, $1 worth of oil—42 gallons—is equal to $3.26 worth of coal. Although oil is very convenient for steam raising, for many reasons it is not much used for this purpose in the United States, simply because at present prices it is more costly to obtain a stated amount of heat from oil than from coal. Even in Pennsylvania, with oil at 30c. per barrel, it cost nearly 50 per cent. more to move a train 100 miles by means of oil than when burning coal. Another potent reason why oil cannot replace coal for steam-raising purposes is that there is not enough of it, even in Pennsylvania. The only region where petroleum can supply the place of coal to advantage is that wherein the Russian product can be distributed at a low price, because the yield of the Baku wells is so large that an extensive consumption of the product for fuel would not affect the price, as in America.

A somewhat different view is taken by others. For example, Mr. S. S. Leonard, in a paper on pretroleum fuel, read before the recent New York convention of the National Electric Light Association, said: As to the economy of petroleum over coal, I have already mentioned that there was a saving of from 20 to 25 per cent. on the cost of fuel, and from 40 to 50 per cent. in labor. From tests recently made by us the following figures were obtained: 111·34 horse power running six hours used 250 gallons of oil costing $5.50, or at the rate of 70 cents per 100 horse power per hour; 104·8 horse power running six hours used 3,461 pounds of coal, costing $5.45, or at the rate of 86 cents per 100 horse power per hour. Another test gave the following figures: 96·45 horse power running eight hours used 4014·75 pounds of coal, costing $6.32, or 80 cents per 100 horse power per hour; 115·54 horse power running 7 hours used 233 gallons of oil, costing $5.05, or 62 cents per 100 horse power per hour. On the above figures oil is from 17 to 32 per cent. cheaper than coal. The highest evaporation made with oil was 14·8 pounds of water per pound of oil with feed water at 103, and with coal 5·38 pounds of water per pound of coal, feed water at 108. The coal used was a good grade of Illinois lump, costing $3.15 per ton, but which is usually worth $3.25.

In the matter of labor, one man can easily attend from seven to ten 150 horse power boilers and then have less to do than he would were he firing one boiler with coal. After a week's run with oil your boiler flues are much cleaner than they would be from the use of bituminous coal for one night, especially Western coal. Your fire room can be kept as clean as your dynamo room. There being no ashes, you are saved the expense of handling them, as well as the dirt, and the former is no small matter where some twenty tons of coal are being used every twenty-four hours. I might say that the above tests were made during a part of the day's run, and it is our opinion that a more favorable showing could be made with the oil where a larger number of boilers are in use. It seems to work better with a good fire than where a small fire is sufficient. With our pipe lines affording a cheap method of transportation, the future of "petroleum fuel" is assured, and I think there is no doubt but with true Yankee ingenuity a burner or some method will be brought forward by which the use of petroleum, as a fuel, will be greatly improved.

In the discussion which followed, Mr. Pope analyzed the figures as follows: 250 gallons of oil cost $5.50; that is, 70 cents per 100 horse power per hour. Coal costs 86 cents per 100 horse power per hour, a difference of 10 cents per 100 horse power per hour.

Mr. De Camp: During a residence of two years in the oil region, I found that the people there who were controlling wells, and who had every facility for getting cheap oil from the various refineries through the country, would prefer to pay as high as $20 a ton for coal. There also would be occasionally a man who would start up with an oil-burning apparatus, but that would be abandoned. Taking those things in connection with the inquiries in Philadelphia and the final results of their efforts there, led me to abandon them.

Prof. Van der Weyde: A year ago I had a rare opportunity to test the economy of coal compared with petroleum. I was testing a new style of dynamo in order to determine the economy of the alleged improvement. The parties interested in it concluded to make another test, and by means of the power from a petroleum boiler. I was glad of that. The petroleum boiler was furnished with a furnace. I had the consumption of petroleum watched carefully. I have not in my memory the correct figures, but I can tell you the upshot of the results obtained. The dynamo was tested also. The steam power furnished to it I had carefully tested with indicator diagrams. I made the test as well as a conscientious scientific application could make it. The result was that, when compared with the consumption of coal, the petroleum was a great deal dearer, notwithstanding that the coal is more expensive here in New York than in many other places. I remember the upshot only, which was this: That, so long as crude petroleum will cost more than 40 cents a barrel, I find it is cheaper to use a slack coal. In stating that result to a prominent Philadelphia manufacturer, he told me that they had had the free use of gasoline from some petroleum factory there, and so they used it for a time until the gasoline got more valuable in the market, and they could not get it gratis any more, and they had to buy it. Then they stopped, because if they had to pay for the gasoline it would be much cheaper to use coal, and they returned to the use of coal. Only where the peculiar circumstances admit of getting pretrolum cheap can it be used to advantage. If that is not the case, it cannot be used to advantage. For instance, in Russia they use petroleum largely because they have no coal; but in the city of New York I am perfectly satisfied, notwithstanding there is some saving in the handling of the fuel when we use petroleum, that coal is cheaper in New York City. The petroleum cost $1 a barrel. The test of the petroleum was for about a fortnight. The plant was not more than enough to furnish about 20 horse power. We used crude petroleum. The arrangement for consuming petroleum was very fine—one of the best I have seen—while the arrangement for the coal consumption may not have been so perfect. It was an ordinary horizontal boiler. I believe we paid $3.50 a ton for the coal delivered at the place. The result of my calculation was that when we could get petroleum for 40 cents a barrel, then we could make steam as cheap as with coal. Another illustration comes to my mind. In the city of Yonkers, at Hastings, there are gas works where petroleum is used to be converted into gas. They commenced with coal as fuel, and after a while they tried petroleum, and, instructed by the experience I had had before with a dynamo, I told them I did not expect they would be satisfied. It turned out that way. They abandoned the use of petroleum and returned to the use of coal.

Mr. Sunny, Chicago: The company that I am connected with has a station just south of the city limits in Chicago. Our coal costs us about $900 a month. We were burning it by the car load. The coal was wet at the mines; it was generally wet when it was weighed; and by the time the car got to us we found it short about 20 per cent. in weight, so we got about $700 worth of coal, and paid $900 for it. On investigating this question of oil burning and corresponding with a large number of gentlemen who had some experience and who had been using oil burners for a long period, we found that in most instances the same results could be had out of two barrels of oil as out of a ton of ordinary bituminous coal. Our coal was costing us about $3 a ton. We could buy oil for 60 cents a barrel, so that the equivalent of one ton of coal would be $1.80, making a saving of $1.20 on a ton of coal. The saving that we expected to get on the change from coal to oil figures at the difference between $957 a month and $540 a month, and we make a saving of $45 for the salary of a coal passer, and $12 for hauling the coal in and taking care of the ashes. We expect to make, in any event, a saving of 35 per cent., although the figures guaranteed to us by the men who are handling oil burners (and the figures are said to be reliable by men who have experimented) would indicate that there will be a saving of 40 per cent.

With regard to Mr. Leonard's figures as to the economy, I should say that this fact ought to be taken into consideration, that the oil cost him perhaps 2¼ cents a gallon in Minneapolis, while it cost 1¼ cents in Chicago. With regard to the burning out of the boilers, I found that that largely depended on whether you could distribute your flues all around the boiler. But there are several methods whereby you can distribute your flame so equally that there will be no effect on the boiler whatever, and you can get the same result out of the use of oil as you get from the use of coal with respect to the burning of the boilers.

Mr. Fred. De Land, Chicago, called attention to an experiment going on at New Orleans that will probably be interesting. It is the Louisiana Electric Light and Power Company. Morris J. Hart is the general manager. He has one battery of boilers running by petroleum, and another running by coal right next to it. They have been using first quality Pittsburg nut coal, floated down the Ohio and Mississippi Rivers, costing $4.50 per ton of 2,000 lb. weight, laid at furnace door. As the cost of petroleum is 25 cents a barrel at Findlay or Lima and 75 cents at the furnace, and as three barrels of oil replace a ton of coal, the saving is 50 per cent. There is no burning out of grate bars, no removal of ashes, no smoke in the boiler room. Mr. Hart said that the only disadvantage that they labored under was in respect to transportation. This difficulty they proposed to do away with by the construction of their own tank floats and depots. This company had their own tanks, costing $14,000. The oil flows from the cars into the receiving tanks and is pumped into reservoirs, passing thence through pipes under the boiler. When the oil is turned on, a jet of steam is made to spread the oil flames, so that cold water in the boiler is converted into steam in twenty minutes or less time.

BRITISH AND AMERICAN COTTONS IN CHINA.

BRITISH CONSUL OXENHAM, at Chin-Kiang, China, says: The import of cotton goods has increased from 13,073,000 pieces to 16,370,350 in 1887, and is the largest import on record since 1872. Gray shirtings have increased some 101,000 pieces, which is said to be due to a slight improvement in quality, to less sizing, accompanied by a substantial decrease in price. I understand that larger quantities of 10 lb. unsized shirtings have been sold this year, while there has been at the same time a heavy demand for 8 lb. sized goods. White shirtings have increased from 108,400 pieces to 111,907 pieces in 1887, and are up to the usual annual import. T cloths have also increased from 97,192 pieces to 107,085. Both these cloths are purchased by the lower middle class of small shopkeepers and well-to-do farmers. *Sheetings and Drills:* In both there is an increase, especially in English sheetings: Americans remain steady. The figures are: English, 7,917 pieces in 1886 to 21,152 pieces in 1887; American, 29,813 to 24,101 in 1887. English drills have increased from 39,890 to 40,390 pieces. In this last class of goods the import is fairly divided between the two nationalities. Drills and sheetings are popular with a limited class, but their high price prevents a large sale; but they are durable, neat, and unsized, thus meeting the wishes of the thrifty Chinese bourgeois. The sudden increase in English sheetings is due to local needs, as the American import into Shanghai has been over the average for 1887. English have probably this year supplanted American, owing to small stock in hand of latter at the close of 1886. The American are most popular: the cotton is better, the cloth whiter, and the texture firmer, but their price is too high. English cheapness counterbalances other disadvantages. The figures are here given for six years:

	1881.	1882.	1884.	1885.	1886.	1887.
	Pieces.	Pieces.	Pieces.	Pieces.	Pieces.	Pieces.
English sheetings.....	2,000	7,900	8,085	4,605	7,190	21,152
American sheetings.....	14,295	14,041	10,225	20,685	29,813	24,101

INDIGO CULTURE IN CHINA.

ACCORDING to the last report of Consul Jones, of Chin-Kiang, the indigo plant is cultivated as part of the crop of every farmer in that province, and after its manufacture into the dye is employed by his family for dyeing the cotton goods used for the clothing of the people. That which is not consumed in this way is put upon the market for sale and exportation. The indigo is a leguminous plant easily cultivated, of prolific growth, and little subject to disease or the ravages of insects. The ground is prepared by the plow and harrow, thoroughly pulverized and enriched by liquid manure, which is in common use by the Chinese in the cultivation of all their crops. As in the cultivation of rice, the seed of the indigo plant is sown in patches of ground, and as thickly as possible. In a month, when the plants are several inches high, they are transplanted into a larger piece of ground, and in rows about eighteen inches apart. From that time until they are required they need very little care, with the exception, in a scarcity of rain, of being occasionally watered. When they reach a height of about two feet, and the leaves have assumed a dark color, they are cut to the ground, and gathered for the manufacturing process. From the roots, when the plants are cut down, another growth springs up, and two crops are obtained in one year. In every farm are a dozen or more large earthen jars or kongs, with the capacity of a barrel, which are used for the manufacture of indigo. Those who engage extensively in the manufacture have a large brick-lined tank built in the ground, six or eight feet in depth, and of a diameter of ten or fifteen feet, with a capacity of many hundred gallons. The plants are placed in these receptacles, and covered with fresh, clear water, where they are allowed to lie for several days till the indican, a peculiar substance contained in the juice of the plant, is decomposed by fermentation. This process is aided by the application of a little slaked lime and frequent stirring, when the indigo is precipitated in the form of a dark blue sediment, which, when dried, forms the indigo of commerce. The quality of the indigo is characterized by its color; the richer and darker the blue, the more it is estimated, and the higher price it will fetch in the market. During the process of manufacture, women with flowers in their hair (a universal custom in China) are not permitted to approach the kongs, as it is a belief that their presence is prejudicial to the quality of the indigo; and for a like reason the kongs are removed to a situation protected from the atmosphere of the fields.

IMPROVEMENT IN THE MANUFACTURE OF PHOSPHORUS.

A. NICOLLE, of Paris, is the author of an improved process of making phosphorus. The mineral phosphate, either natural or artificial, is treated with nitric acid, and then, on the addition of potassium sulphate, the calcium is precipitated as sulphate. This is removed by filtration, and mercurous nitrate in proper quantity is introduced. The phosphate of mercury thus obtained is distilled with carbon, when first mercury and then phosphorus are distilled over. To the calcium nitrate solution more potassium sulphate is added, and the resulting potassium nitrate crystallized.

MODIFICATION OF HARCOURT'S COLOR TEST.

By WILLIAM G. HICKS, Assistant Engineer of the Ramsgate Corporation Gas Works.

As promised in my article appearing in last week's *Journal*, I will now give a description of the modification of Harcourt's color test which I have used with great success.

Referring to the illustrations, A is the platinized pumice bulb; B is the test glass for sulphureted hydrogen, with acetate of lead paper suspended in the tube 1; C is a test glass, to be placed second in testing for ammonia and carbonic acid. It is provided with a tube, 2, partly filled with beads. The rest of the apparatus is the same as Mr. Harcourt's, except the measures, which are divided into cubic centimeters.

Test for Ammonia.—Place a measured amount of standard solution of sulphuric acid (the same as is used with the bottle described in my previous communication) into the test glasses—about two-thirds into No. 1 and one-third into No. 2 (see Fig. 2). The solution put into No. 2 should be passed through the beads in the tube 2; fill up with distilled water, if necessary; connect to the aspirator as shown; then attach the inlet of No. 1 test glass to the tube from which the gas is issuing; and turn on the tap of the aspirator to give a very thin stream. Having allowed one liter of gas to pass, note the amount of exhaust shown by the gauge on the top of the aspirator. Now disconnect from the gas supply, and pass about 20 c. c. of air; disconnect the test glasses; wash down the beads of No. 2; and titrate with standard solution of potash. The corrections, etc., are the same as described in the last article, except that the exhaust in the top of the aspirator affects the volume of gas, and should be corrected for as described below.

Test for Sulphureted Hydrogen.—A measured quantity of standard solution of acetate of lead is placed in one test glass (B), as indicated in Fig. 1; and gas is aspirated through until the solution is saturated with sulphureted hydrogen, which is shown by the lead paper suspended in the tube (Fig. 1) just turning brown at the lower edge. The amount of water let out of the aspirator having been noted, the calculation is as follows: Say 10 c. c. of standard lead solution was placed in the test glass, and it required 1,385 c. c. of gas to saturate it with sulphureted hydrogen, then as 1385 : 1000 : : 10 = 7·22 c. c. of sulphureted hydrogen per liter. Now correct for temperature and pressure. A small piece of wool should be placed in the bottom of the tube 1, so as to prevent the solution from soiling the lead paper.

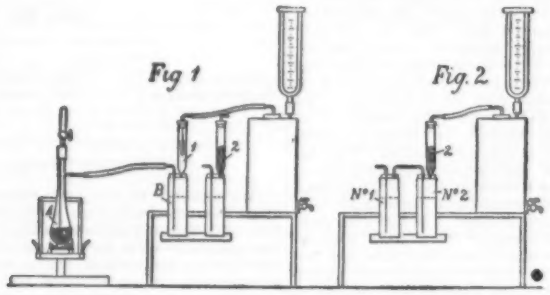


Fig. 1 Fig. 2.

Test for Carbonic Acid.—Standard barium hydrate solution is placed in the test glasses, in the same manner as described in the test for ammonia; and one liter of water is let out of the aspirator. Then 200 c. c. of air (which has been previously freed from carbonic acid by being sent through a small quantity of barium hydrate solution) is forced through. A piece of wool or other material should be placed in the outlet of the vessel containing the barium hydrate, so as to prevent any being carried forward into the test glasses. Color with phenol phthalein, and titrate with standard hydrochloric acid.

Carbon Bisulphide.—This test is the same as that given for sulphureted hydrogen, only the gas is drawn through the platinized pumice bulb of Harcourt's color test, to convert the bisulphide of carbon into sulphureted hydrogen. The result in cubic centimeters, after correction, should be divided by two, and will then equal the volume of bisulphide of carbon in the gas.

Corrections for Exhaust, etc.—For example, suppose that we found 12·5 c. c. of carbonic acid in one liter of gas (as measured by the water let out), with the thermometer at 68° Fahr., and the barometer at 29·8 inches; and that the gauge on the aspirator showed 6¼ inches exhaust on a column of water: Subtract ½ inch from the height of the barometer for this 6½ inches exhaust; then as the tabular number 956 : 1000 : : 12·5 = 13·07 c. c. per liter, or 1·307 per cent.

The test solutions used for absorbing ammonia and carbonic acid should be at least 10 c. c. in excess of the amount actually required to combine with the quantity of these gases that are likely to be present.

For sulphureted hydrogen, I find about 10 or 15 c. c. a convenient amount of acetate of lead solution; passing gas until it is saturated, as mentioned above.

The bottle described in my last communication makes a very convenient liter measure for the above tests, especially when used in conjunction with a smaller measure with finer divisions. It will be noted that the bisulphide of carbon test can be performed most accurately in a few minutes; and that by adding 6 or 7 grains to the bisulphide of carbon found (after converting it into grains per 100 cubic feet), the operator will have the total sulphur compounds present in the purified gas.

In conclusion, I may say that this apparatus is portable, and, in my opinion, far superior to the old form; and I consider that the methods of using it described in this article will give the operator most accurate results.—*Journal of Gas Lighting.*

BUILDERS in Germany have for some time found that a compound of cork, lime and sand, moulded into bricks, makes partition walls that are light and stop sound and exclude heat and cold better than common brick.

MR. FLINDERS PETRIE'S DISCOVERIES IN EGYPT.

WHAT tropical vegetation has done for Central America and Hindostan in concealing their architectural remains, the sands of the desert have done for Egypt, and many of those marvels which astonished the antique world have lain covered up from the eyes of men for generations uncounted. The art of Egypt, as expressed in architecture and sculpture, has, as we know, suffered much, as in other Eastern lands, from the action of earthquake, and of war, no less blindly pitiless and fitful. But in this, as in many other respects, the individuality of Egypt is emphasized, and Time's effacing fingers in her case creep over her untiringly in the shape of desert sands.

The great Sphinx, looking far over the plains at Ghizeh with its calm eternal eyes, was, till the other day, buried neck-deep in the desert drift, and it may be almost said that the Pyramids alone have been able to spurn the effusive and ever-persistent advances of the wilderness. There are, however, countless cities in the Delta which have been submerged for many centuries under a perfect Zuyder Zee of sand, and it is only when travelers like Mr. Flinders Petrie, gifted with knowledge and sustained enthusiasm, and endowed with all the instincts of the explorer, address themselves to uncovering those lost and forgotten centers of the public life of the distant past, that we begin to realize for ourselves the startling relevancy of that past to the present. The Assyrian sculptures brought to this country by Layard give a far better idea of the grandeur of that city by the Tigris whose founder was a mighty hunter before the Lord, than whole libraries of written matter. So, again, the gilded mummy cases with their painted portraiture—which their discoverer, Mr. Flinders Petrie, is now exhibiting to the public in the Egyptian Hall, Piccadilly—are quite a revelation, especially as regards the limner's art during the Roman occupation of Egypt—or, to be a little more precise, during the second and third centuries of our era. This marvelous find enables us to follow the history of art in its transition from the stereotyped forms of Egypt to the lifelike paintings of Græco-Roman art.

Mr. Flinders Petrie seems to have devoted his life to Egyptian research, and during the last seven or eight years has spent every winter in Lower Egypt and its neighborhood. But it was in the spring of this present year that, searching for the remains of the Labyrinth described by Herodotus—which he not only discovered, but was able also, by means of a fragment of hieroglyphed limestone, to identify the pyramidal tomb of its builder, Amenemhat III., of the 12th Dynasty—he happened upon an extensive cemetery belonging to the Græco Roman period. And here, again, the individuality of Egypt asserts itself, in the view of that wonderful civilization which is the fountain head of all our western knowledge, yielded not only by her palaces, but by her tombs. This cemetery or necropolis covers about a hundred acres, and Mr. Flinders Petrie makes its existence known to the world for the first time. It appears to lie near the site of the Labyrinth which for so many ages was the wonder of the world. Mr. Petrie has exhumed hundreds of mummies and countless objects of interest buried with the dead—such as amulets, funerary vases in limestone, in which the Egyptians placed the viscera of the departed, and other objects. The lids of these canopic vases represent the heads of various animals, such as the hawk, the jackal, the ape, and others; while the vases themselves are quite classical in their contour. Some of these, as well as several of the children's toys, including a bedstead, a terra cotta sedan chair, an incense burner, a rag doll, and a couple of tops such as British boys spin to-day, a tinned copper mirror, a set of leather workers' needles, a round glass lens for concentrating light, such as our policemen carry in their lanterns, a wheel bird, a flint knife, a child mummy, are among the numerous articles; but what is most interesting to the art student is the splendid series of portraits painted on panel with a wax medium. They are mostly full-face and life-size, and were fastened over the faces of the elaborately bandaged mummies. In most instances, the body itself is crossed and recrossed diagonally with narrow bands of a white woven fabric, so as to form a pattern of sunken lozenges, in the centers of which are small round gilt knobs. The manner in which this lozenge-shaped opening, by slight gradations, narrows itself to the bottom is mathematical in its nicety, and the general effect is rich and soft.

With the thorough conviction of the soul's immortality, the Egyptians in all ages did their best to make death beautiful; but in the Ptolemaic and Antonine epochs Greek art, which is the presentment of Nature herself, was grafted on to Egyptian conventionality, and beauty was crowned with joy. "Think not of the wan, sunken face within," the artist seems to say to us; "but remember your dear lost one as she lived, with the glow of life quivering on her cheek and the light of life beaming from her eye." These heads are by various artists, some of them wielding a brush as vigorous as that of Velasquez, and others a pencil as delicate and refined as that of Sir Frederick Leighton or Bouguereau. There is no mistaking the fact that they are all veritable portraits of men and women who have been coffined these seventeen centuries, and it is earnestly to be hoped that Mr. Petrie's matchless treasures will find their ultimate home in the National Gallery and British Museum.—*J. F. R., in Illustrated London News.*

THE FORTH BRIDGE.*

By F. E. COOPER, M.I.C.E., Resident Engineer.

To the request to prepare a paper on the Forth Bridge for the present meeting, I at once assented, on the understanding that it should take the form of a continuation of that communicated to the Institute on the occasion of their visit in 1885 by Mr. B. Baker, who, with Sir John Fowler, is joint engineer of the structure.

I, therefore, propose to confine myself principally to a general description of the methods employed in the erection of the various portions of the main spans, and, in doing so, must crave the indulgence of my audience if at times I appear to be guilty of the sin of plagiarism.

My excuse must be that the interest excited by the great work—the subject of this paper—having called forth so many descriptions, some of great technical interest, communicated to scientific and learned societies, others appearing in the periodicals devoted to engineering and kindred matter, and others, again, of more popular interest which have formed the subject of newspaper articles and pamphlets more or less correctly inspired, I experience very great difficulty in finding anything novel, or of special interest, to claim your attention.

As it is possible that some of those present have not clearly in their minds the information contained in Mr. Baker's paper of 1885, before referred to, I will first give a short summary of its contents.

The Forth Bridge is the most important link in the direct railway communication which the North British Railway and their allies, the Midland Railway Company and the East Coast Companies—the Great Northern and the North-Eastern Railway Companies—are seeking to complete between Edinburgh on the one hand and Perth and Dundee on the other, which will enable them to compete with the West Coast Companies for the North of Scotland traffic on equal if not more favorable terms.

Parliamentary sanction for the present route of this communication was obtained in 1873; but it was not until 1882, after reconsideration of the original design of the structure crossing the Forth, and the adoption of that now being carried out, that anything definite was commenced.

The total length of the viaduct will be 8,296 ft., or nearly 1⅝ miles, and there are two spans 1,710 ft., two of 680 ft., fifteen of 168 ft. girders, four of 57 ft., and three of 25 ft. being masonry arches.

The clear headway for navigation will be not less than 150 ft. for 500 ft. in the center of the 1,710 ft. spans. The extreme height of the structure is 361 ft. above and the extreme depth of foundations 91 ft. below the level of high water.

There will be about 53,000 tons of steel in the superstructure of the viaduct, and about 140,000 cubic yards of masonry and concrete in the foundation and piers.

The main piers, three in number, consist each of a group of four masonry columns, faced with granite, 49 ft. in diameter at the top, and 36 ft. high, which rest either on the solid rock or on concrete, carried down in most cases by means of caissons, of a maximum diameter of 70 ft., to the rock or bowlder clay, which is of almost equal solidity.

The stresses to be provided for are those arising from the weight of the structure itself, the rolling load, and wind, as well as from change of temperature.

The rolling load had been taken as 1 ton per foot run on each line of rails over the whole structure, or a train on each line consisting of sixty short coal trucks of 15 tons each, headed by 2 locomotives and tenders weighing in the aggregate 142 tons.

The wind-pressure provided for is a pressure of 56 lb. per square foot striking the whole or any part of the exposed surface of the bridge at any angle with the horizon, the total amount on the main spans being estimated at nearly 8,000 tons.

The material used throughout is open hearth or Siemens-Martin steel. That used for parts subject to tension is specified to withstand a tensile strength of 30 to 33 tons to the square inch, with an elongation in 8 in. of not less than 20 per cent.; that subject to compression only, a tensile stress of 34 to 37 tons per square inch, with an elongation in 8 in. of not less than 17 per cent. Strips of each class 1½ in. wide are to bend cold round a bar, the diameter of which is double the thickness of the strip. The tensile strength of the rivet steel is 26 to 30 tons per square inch.

The superstructure of the main spans is made up of three enormous double cantilevers resting on the three piers before mentioned. Those on the shore sides are 1,505 ft. and that on Inch Garvie (an island fortuitously dividing the deep water space into two channels of nearly equal width) is 1,620 ft. in length; the effective depth over the piers is 330 ft., and at the ends 35 ft. The center portions of the two 1,710 ft. spans on each side of Inch Garvie are formed by two lattice girders 350 ft. in length and 50 ft. deep in the center, and 37 ft. deep at the ends.

The compression members of the cantilevers are, as a rule, formed of tubes either circular in form or circular with flattened sides.

The tension members are girders quadrangular in section; the booms at their corners take the strains, and the vertical and horizontal bracing of the sides keep them stiff against the effects of their own weight and wind respectively.

The steel is delivered at the works in plates cut nearly to size, and as angle bars of various sizes and lengths.

Plates which have to be bent or shaped are so treated at a red heat in hydraulic presses with moulds of special construction, and all edges are planed.

The plates and bars, whether composing circular members or the booms of the girders, with all the required covers, etc., are as a rule assembled in their exact positions, and operated upon by drills of special construction, which, traversing their whole length, bore nearly all the holes required for the riveting.

I will now proceed to describe in as concise a manner as possible how the superstructure of the Forth bridge has up to the present time been erected, and what modifications were found advisable during the progress of the work.

It will be convenient to divide the subject into the three following principal groups.

---

* Paper read before the Iron and Steel Institute at Edinburgh.—*From Engineering.*

I. The erection on timber staging, giving support from beneath, by the use of ordinary derrick cranes.

II. The erection by special appliances placed on extensive platforms, or scaffolding, which varied in position according to the progress of the work.

III. The erection by means of special cranes, which, resting on the members themselves, enabled the latter to be extended, and in turn become the support of the former.

This last system allowed the use of temporary appliances to be reduced to a minimum.

GROUP I.—The first plates of the superstructure comprised in this division, that were dealt with, were the lower bedplates, which rest on the masonry piers, and ultimately transmit to them the whole weight of the superstructure, rolling load, etc. The plates forming these were put together upon iron supports sufficiently high to enable the girders carrying the holders-up of the hydraulic riveters to be manipulated beneath.

Under ordinary circumstances the upper bedplates would be the next parts put together, but the skewbacks, as the massive junctions at this point are termed, and of which they formed the foundations, were not as a rule sufficiently advanced to enable this to be done. Therefore, to save time, the tubular bottom members between the skewbacks were first erected and riveted in their ultimate position, and in some cases, for a similar reason, the transverse and diagonal bracing girders were completed at an early stage. As soon as it was possible to obtain them, the upper bedplates and skewbacks were erected, the former, as in the case of the lower bedplates, in an elevated position, for convenience in riveting, being afterward lowered. Next those portions of the vertical columns, diagonal struts and bottom members over the piers and first struts and bottom members of the first bay of the cantilevers, extending to about 40 ft. above or beyond the masonry, and within reach of the ordinary derrick cranes, were placed in position.

The timber used temporarily in the staging for the support of these amounted to about 10,000 cubic feet in the case of Queensferry and Fife piers, and rather more at Garvie, and the amount of steel thus erected was about 2,000 tons in each of the two former, and 2,600 tons in the case of Garvie.

The point was now reached at which the appliances under Group II. were brought into play, and it was only after careful and protracted consideration that the system made use of was adopted.

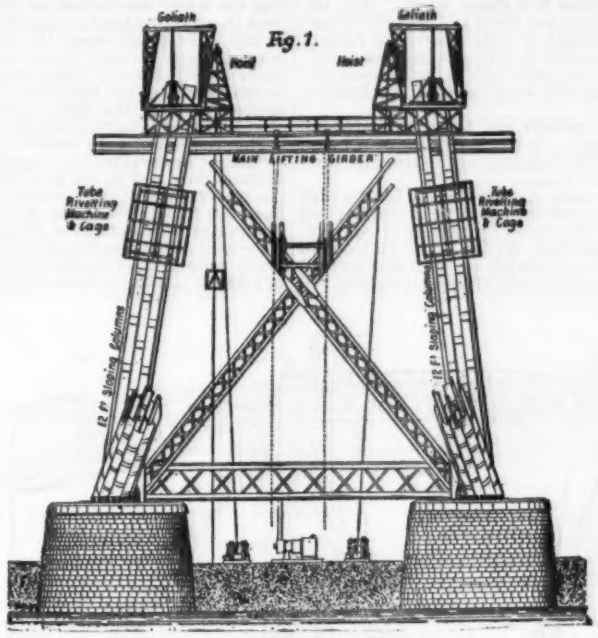
The principal conditions laid down with reference to the central portions of the double cantilevers were:

1. That in order that the men should be able to work at any height in as great security and comfort as if on the level of the ground, platforms or scaffolding of considerable area should be provided.

2. That the raising into position of the several parts of the structure should be as little as possible interrupted by wind, the ordinary derrick cranes not being then considered applicable.

3. That the weight of the platforms and apparatus should not much exceed 400 tons.

Fig. 1.



THE FORTH BRIDGE.

4. That the connections forming the supports should not bring excessive strains upon any part of the permanent structure.

5. That no rams of the lifting apparatus should have to exert a lifting force of much more than 100 tons.

6. That the platforms should form ultimately stages for building the top members over the piers.

7. That, for the sake of economy, material forming part of the permanent structure should be made use of temporarily as much as possible.

The platforms provided were two in number, one on each side of the axis of the bridge. They were 20 ft. wide, and 200 ft. long at Fife and Queensferry, and 350 ft. long at Garvie, composed of timber planking and joists, which rested on two longitudinal girders, one on each side of the vertical columns, formed of part of the booms and bracing of the first permanent ties of the cantilever. These were carried by cross girders, constructed of plates forming part of the second and third permanent struts, passed through the northern and southern pairs of vertical columns, respectively, plates being temporarily omitted for the purpose. A double set of short cross girders inside each vertical column formed the supports for the hydraulic jacks, which raised, when necessary, the cross girders first referred to, and with them the platforms. The cross girders inside the columns were supported by means of pins passing through their ends, and through the webs of the I beams forming part of the vertical columns. The main lifting rams were 13½ in. in diameter, and were capable of lifting 240 tons with the water supplied to them by special pumps, at a pressure of about 30 cwt. per square inch. The total weight actually lifted by the four rams did not, as a rule, much exceed 450 tons, exclusive of friction.

The plates and beams forming the vertical and diagonal columns were raised by ordinary hoists to the level of the platforms. These were then taken by small trolleys to a goliath, running along temporary rails on the surface of each platform, which lifted them into and held them in place while they were bolted to those previously built. Riveting machines, of special and ingenious design, suspended below the platform, dealt with those portions of each tube allotted to them. As soon as a 16 ft. length of the vertical columns was riveted below, and a similar length added above, the hydraulic jacks were set in action, and the platforms were raised, by successive steps of 1 ft., a height of 16 ft., when the above described operations of building and riveting were resumed.

In this way those on the center portion of the Queensferry cantilever were raised the extreme distance of 281 ft. in about twenty-four weeks. The platform girders were then trussed by links formerly used in old Hammersmith Bridge, and upon them the massive girders forming the top members of the cantilevers, between the vertical columns, were put together and riveted. The timber platform was then laid upon the latter, and the lifting platforms and their girders and other apparatus were taken apart and lowered piecemeal.

The lower members of the cantilevers, formed of tubes 12 ft. in diameter, were extended outward from the piers for about 40 ft. by means of ordinary cranes. Beyond that point they were erected by means of an ingeniously devised crane, fitted with hydraulic lifting, turning, and traversing gear. This crane was seated on a carriage movable along the top of a framework 20 ft. square and 48 ft. long, first built in sections upon and surrounding the tube itself. As each section of the latter was completed in front (the men employed in bolting up, etc., standing on the timber flooring supported on the bottom of the framework), the crane was used to transfer the sections of the framework, previously unbolted, from the back to the front, and in this way the tube, by successive operations, was built out for a distance of about 160 ft. from the piers.

As in the case of lifting platforms for the central portion, the objects kept in view in the design of this apparatus were large working platforms for the men and for the putting in place of material cranes actuated by hydraulic power with a short lift.

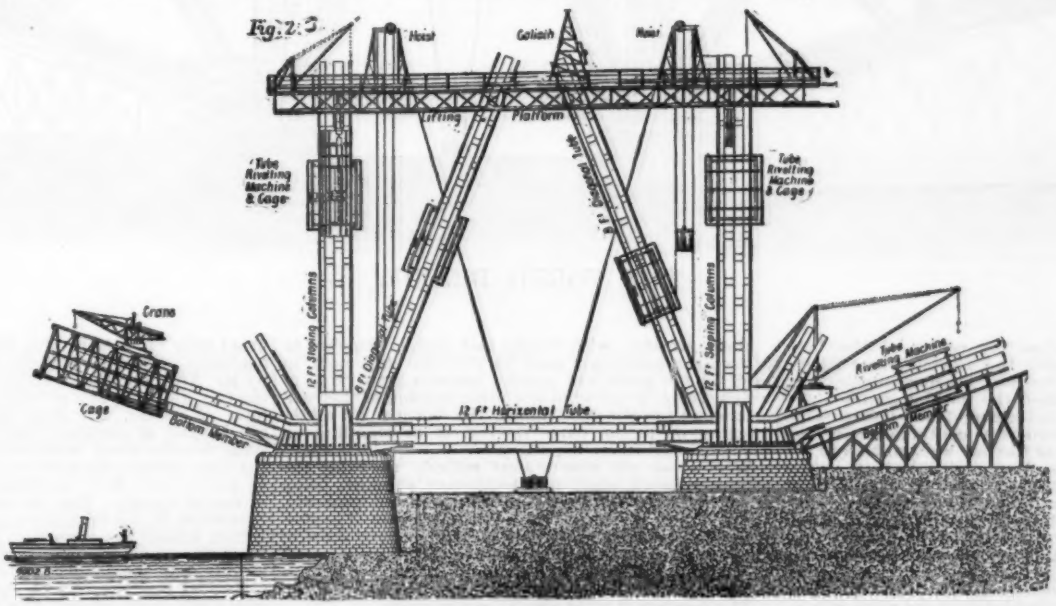
For the erection of the lower portion of the first strut, and of the first vertical tie and support to the internal viaduct, lifting platforms, similar to but smaller than those first described, raised by jacks placed in the vertical tie and on the vertical columns, were used. These were originally intended to have been carried up to the level of the under side of the top members, and upon them, when strengthened, those members were to have been built; but the experience gained up to this time as to the ability of the men to work unaffected in situations more exposed than was at first deemed advisable, as well as to the ease with which large and heavy pieces of material could be raised great heights by ordinary cranes and tackle with little interruption from anything but a strong wind, rendered it possible for a great modification to be made in the mode and apparatus made use of, and these platforms were carried no higher than the level of the intersection of the first ties and struts.

The appliances used on the erection up to this point, though amply fulfilling all the conditions of the problem, were necessarily slow in action, and costly to make, put together, and take down; and it must be borne in mind that when the vertical columns, with their bracing and top and bottom members connecting them, were completed, an immensely powerful support was available, from which the other members of the cantilever and the internal viaduct could be held up by temporary stays as securely as if supported by staging on the solid ground below.

The weight of the portions of Fife and Queensferry cantilevers erected under Group II. was about 5,000 tons each; at Garvie it was somewhat more.

Group III.—With the exception of the first bay of the

Fig. 2.



THE FORTH BRIDGE.

lower members, the first 120 ft. of the internal viaduct, and the lower portion of the first struts, the whole of the principal members of the cantilever are included in this group.

Two types of special cranes are employed, one made use of to build the top members and upper halves of the struts and ties. The other is traversed along the internal viaduct, and deals with the remainder of the work. The top member crane is provided with a horizontal jib, 85 ft. in length, which can be slewed through an arc of 230 deg., and along which the suspending pulleys can run. The lifting of the material is effected by

a steam winch, the main drum of which accommodates about 400 ft. of wire rope 1¾ in. in circumference. This crane is supported on a carriage, formed of two steel cross griders strongly braced, and which rests on the upper surface of the angles connecting the vertical webs to the flanges of the booms of the top members, and along which, when desired, it is traversed by means of powerful screws.

In some cases, at the back of the carriage a hydraulic crane is attached, along the horizontal jib of which run the supports for a hydraulic riveter, used for completing that part of the work within its reach. An ordinary derrick crane is sometimes substituted for this part of the apparatus.

Beneath the top member, and strongly attached to the carriage of the crane, is suspended, on four longitudinal girders, a roomy platform of timber, 76 ft. long and 45 ft. wide. The building operations are thus carried on. Each length of the vertical webs of the top members is first raised by the ordinary hoist to the level of the internal viaduct. It is then carried on a trolley to a point beneath the jib of the top member crane, which raises it to its exact position, and holds it there, while the men standing on the platform bolt it to that already complete.

The lower booms are first thus secured, then the vertical and horizontal bracing bars are fixed, and lastly the top booms. When the length is complete, the carriage is slid down a convenient distance, and the building operations are again resumed, and are continued until the member reaches the center of the bay. When, in the case of bay 1, the overhang was 125 ft., and the strain on the vertical bracing (temporarily doubled) had nearly reached the working strain of 6½ tons per square inch, with the end of the members deflected about 8 in., a temporary continuation of the vertical tie in the center of the bay was built up to the under side of the top members, and jacks being interposed, the latter were raised the amount they had deflected, and secured by wedges.

Similar extensions of the vertical ties will be required in the case of the other bays in order to support temporarily and adjust the top members above them.

The crane then continued the building until the top members reached the junction at the upper ends of the first struts, where any deflection in them was again removed, and the permanent connections at this point were completed.

At convenient intervals, the building of the top member was suspended, and the crane employed first in building down the ties, which operation was similar to that already described for the top members, except that the men occupied stood on small timber stages suspended from and enveloping the member, and which were lowered as required by ordinary tackle. Afterward, the upper halves of the struts were built in the same way, except that the extension was in the reverse direction.

In order to prevent excessive strain on the unsupported lengths of both ties and struts, temporary struts from the vertical columns were put in where required, light girders and wire ropes being also largely made use of.

The internal viaduct crane consists of two masts and jibs of the derrick type, the former in line transversely with the axis of the bridge, and 16 ft. apart, braced strongly together, and secured to a movable timber frame traversed along the outer rail troughs of the viaduct. Each jib is raised and lowered by means of a wire rope passing round a drum on the mast, but the wire rope lifting the material is passed through a sheave at the extremity of the jib; thence it is led over a sheave down the center of the mast, and by means of guide pulleys to some convenient point on the finished structure, thence to a steam winch. The object of separating the power from the crane is to lessen the weight concentrated at that point, the viaduct there being extended much in advance, and, as a rule, acting as a cantilever, its outer end being temporarily supported by wire ropes to some part of the finished structure.

When the viaduct girders are being extended by these cranes, little staging is required, the men being able to do the bolting up standing in the troughs forming the top and bottom booms.

To provide the necessary standing room for the men when at work on the lower members, light platforms of timber are hung from the tubes by trusses of convenient form. For the building of the lower portions of the struts and ties the same stages are used as described in the case of the upper portions of these members.

Steam winches, with blocks and tackle attached to convenient points, are used to lift into and hold in position the parts, not usually exceeding two tons in weight each, of the wind and other bracing of the various members, the men doing the bolting up either hanging on to the parts themselves or standing on planks placed where necessary.

Wire ropes are now almost entirely used for the cranes, running gear, and temporary support, being found most trustworthy, and when treated properly, should never give way. An extensive series of experiments has been made with regard to the proper use of this material, and as a consequence the following conditions are adhered to as much as possible:

The material should be crucible cast steel.

The number of wires should be numerous.

The diameter of the pulleys or drums should not be less than six times the circumference of the rope. A marked increase in the life of the rope is observed when even this proportion is exceeded, the number of bends under load before beginning to fail with six circumferences being 5,000, and with eight circumferences 10,000, while destruction occurred at 15,000 and 36,000 bends respectively.

Riveting.—The riveting of the bottom members of the cantilever, of the vertical columns, and of portions of the diagonal struts between them, has been executed by hydraulic riveters of special design, the principle of which has been to use independent rams for the holder-up and the snap. The holder-up could be traversed along a girder usually pivoted so as to revolve on the axis of the tube, or with its ends moving in a race, so that the girder moved round the tube parallel to its axis.

In both cases the holder-up preserved its direction normal to the surface. The snap was fixed in a ram which also could be traversed along a girder, the latter being movable parallel to the axis of the tube, with its ends traveling in slots formed in rings surrounding the tube. By this arrangement of motions both holder-up and snap could deal with every rivet. The operation of riveting was as follows: The rivet, properly heated, was placed from the inside into its hole, the holder-up was brought opposite to it, the valve admitting the water was turned on, the holder-on thrust the rivet in up to the head, and held it there, while the ram on the outer girder closed the rivet, the same valve admitting water to both rams, but a slight check in the branch leading to the outer ram permitted the rivet to be sent home by the inner ram before the pressure was applied to form the snap. About 800 rivets could be closed by this apparatus in ten hours.

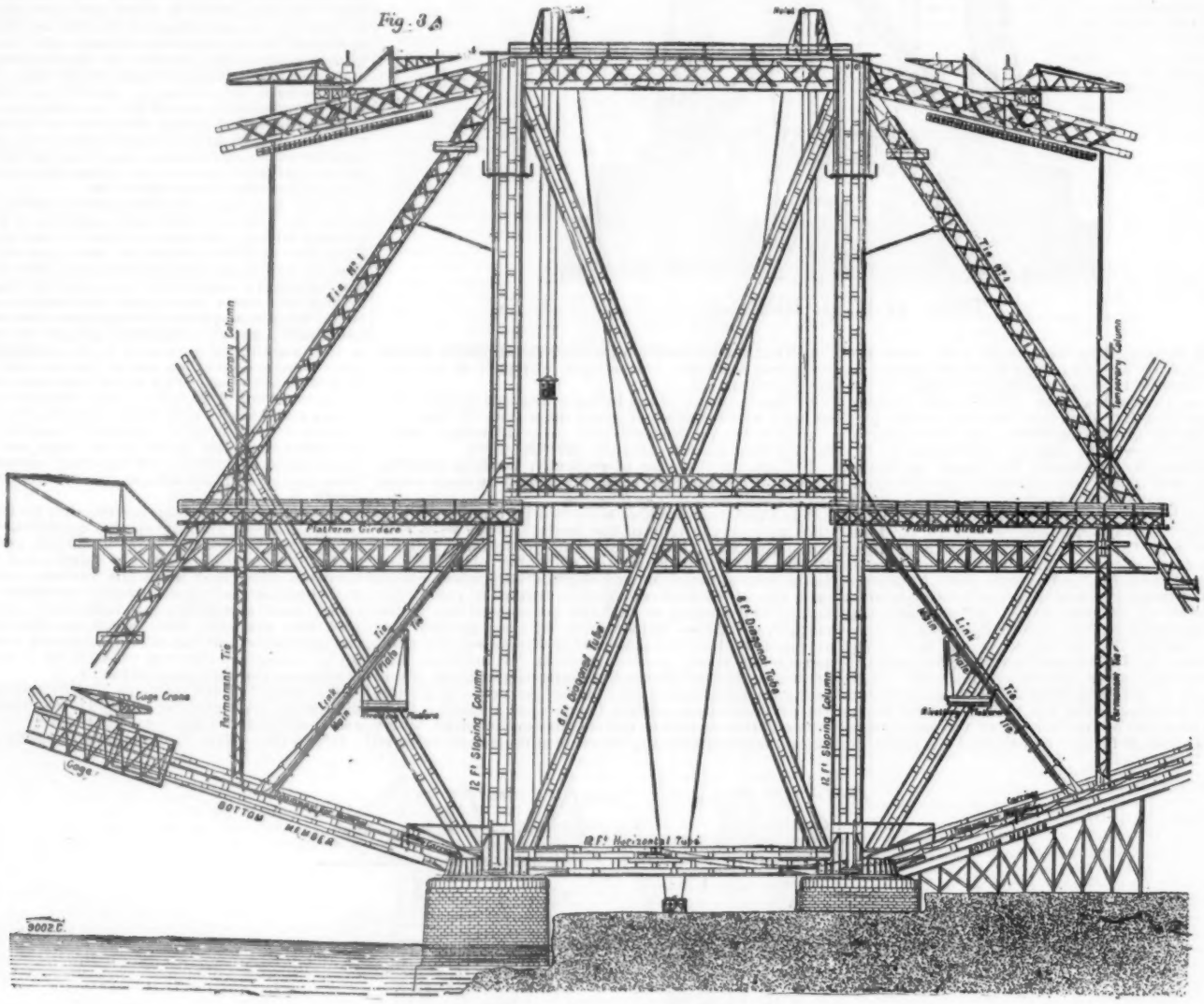
The bedplates, both upper and lower, were riveted by similar apparatus, but simplified, inasmuch as plane surfaces only had to be dealt with. For the interior parts of the skewbacks, where the space was too confined for hand riveting, or for the use of rams of ordinary size, special rams of small size, 4 in. in diameter, were used as holders-up and snaps, the necessary power being obtained by multiplying the ordinary pressure of 1,000 lb. about six times, by the use of an apparatus fitted with rams 4 in. and 10 in. in diameter. Grab machines of various patterns were designed and made by Mr. Arrol for the riveting of the top members, for the ties, and for parts which could be reached by this form of riveter. Mr. Arrol has also greatly simplified the subject of riveting by designing and constructing small reverberatory furnaces for heating the rivets by the blast furnace residual oil, delivered in a fine spray by air at about 20 lb. pressure, through a disintegrator of special design. This has been a great success. The regulation of the heat is complete, the rivets are uniformly heated, the apparatus is more economical than hand fires, and is under perfect control. It is also cleanly, and the danger from fire is much reduced.

A small furnace, 1½ ft. square and 4 ft. long, will heat 2,000 rivets per day, at a cost for oil of about 4s.

As the material used in the construction of the Forth bridge is of special interest to the Iron and Steel Institute, I may be permitted to say that the experience gained by the manufacture of nearly 50,000 tons of Siemens-Martin steel work enables us to say that nothing could be better than its behavior. Plates and bars have been obtained from several distinct firms, and in every case the utmost uniformity has been found, and any variation has been in the direction of improved ductility. Where 20 per cent. elongation has been required, 25 per cent. has, as a rule, been obtained, and in the harder material it has been increased from 17 to 20 and above without any difficulty. The cold bend tests are marvelous, as the specimens exhibited show.

The analyses made in the course of manufacture of

Fig. 3.



THE FORTH BRIDGE.

the steel show that the proportions of the different principal components are generally as follows:

—	Thirty to Thirty-three Tons per Square Inch.	Thirty-four to Thirty-seven Tons per Square Inch.
	Difference per cent. Iron.	Difference per cent. Iron.
Carbon	0·19	0·23
Silicon	0·23	0·03
Sulphur	0·024	0·024
Phosphorus	0·046	0·046
Manganese	0·69	0·69

It is hardly necessary to remind you that Sir John Fowler and Mr. B. Baker are the engineers of the undertaking. They have furnished designs with great minuteness of detail for every part of the permanent structure, and have personally supervised the manufacture and erection, the methods made use of in the latter having been considered and advised upon by them.

Mr. Arrol is the responsible representative of the firm of contractors intrusted with the work, and he has arranged for and carried out the manufacture of the steel work, including the design of the numerous special machines, such as multiple drills, bending presses, and others necessitated by the large amount of material to be dealt with, as well as the varied apparatus and machines described in this paper as employed in the erection. He has in all these been ably assisted by his engineering manager, Mr. A. S. Biggart, A.M.I.C.E., to whom I am much indebted for the loan of the cartoons made use of to-day, which were prepared by him to illustrate a paper read by him before the Institution of Engineers and Shipbuilders in Scotland, on January 24, 1888.

THE DISCUSSION.

Sir Lowthian Bell was the first speaker, but he merely rose to introduce to the meeting Mr. T. C. Clark, of New York, who the speaker stated was one of the leading authorities in America on the science of bridge construction, and whose opinion on this subject could not fail to command the fullest respect of all engineers in every country.

Mr. Clark, in response to the invitation to speak, commenced by stating that the construction of this bridge was so novel and so entirely different to anything before undertaken that it was with the greatest modesty he ventured to give an opinion. There were, however, one or two points on which he could speak with certainty. First, the bridge not only looked strong, but it *was* strong. Its broad-bottomed configuration spoke of a structure destined to stand the roughest usage of the elements. Here indeed was a bridge that no wind, no gale, no tornado could upset. It was a mighty object lesson in permanent stability. It was also admirably adapted to support its own vast superincumbent weight and the moving load it was its mission to bear. All the compression members were tubes, while the extension members were lattice girders; thus showing how just an appreciation its creators had of the best disposition of material to the work to be done. Like all great engineering designs, this was notable for the simplicity and harmony of its parts. All was arranged in a plain, common sense manner. When a strain had to be taken, it was carried directly to the part designed. There was no crossing to and fro, no development of zigzag courses to absorb material needlessly, and create weakness where strength should be. There was a concentration of material along the lines of strain, and large parts were used, by which less surface was exposed to wind pressure; wind pressure, it must be remembered, being calculated at double the strain of the train load, supposing the bridge were covered from end to end. Another point of novelty in the building of this bridge was that the engineering shops for its construction were brought to the site of the bridge; but this was desirable, if not altogether necessary, from the magnitude of the work to be done.

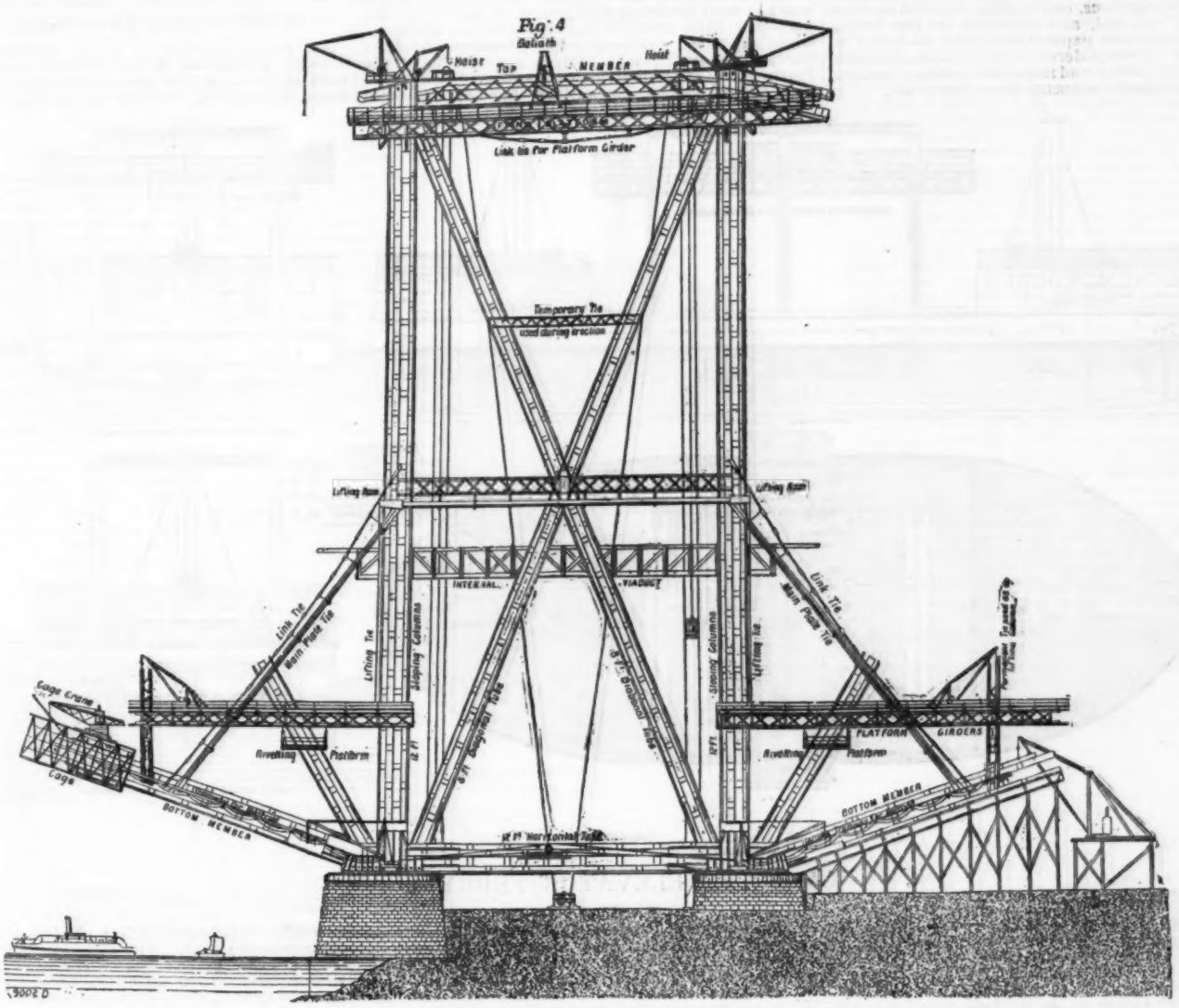
In speaking of the method of construction, Mr. Clark said that the formation of the joints of the enormous tubes had always been looked upon in America as one of the great difficulties in carrying out the work. He, for one, had wondered how this was going to be done, but when he came to the works and saw how clearly all the arrangements had been made—how models were constructed, parts prepared and fitted, all so harmonious and well ordered—the difficulty was no more existent than when Columbus stood the egg on end. It was the old story of the simplicity of genius triumphant over difficulties. Another point that had exercised his mind was the manner in which the central girder was to be put in place between the two overhanging cantilevers, but here again there was simplicity where confusion might so possibly have intruded. The sliding joints which would allow for expansion and contraction in the finished structure were to be temporarily made rigid, and the girder would just be built out from each end as an extension of the cantilever until the two parts met in the middle, when they would be joined up and the sliding joints relieved. Mr. Clark wished to indorse the high terms in which Mr. Cooper had spoken of the material. In this steel they had not only a metal of great strength and endurance, but also one of complete uniformity. That was a point of the greatest importance, and it could be obtained by using this beautiful material, mild steel. There was one point in constructive practice, however, in which there was a difference between English and American methods. In his country they were not in the habit of drilling steel as in Britain, but punched their holes and then rimered them after. This statement elicited scarce suppressed exclamations of horror from many parts of the audience; notably, it seemed to us, from the region of the presidential chair and the neighborhood where Mr. James Riley was sitting. This practice, Mr. Clark added, in evident recognition of the emotion his statement had produced, afforded an excellent inspection of the material. He considered a plate that would not bear punching should not be incorporated in the structure, and he looked on a punched and rimered hole as being as good as a drilled hole.

Returning to a consideration of the bridge as a whole, the speaker said that, when completed, it would be found to be a great architectural creation. Until it was stripped of its scaffoldings and stagings, no definite opinion could be formed of this aspect of the design, but architectural beauty could not otherwise than exist in a structure so simple and so harmonious. It was true it possessed no ornament constructive or designed. Neither did the Pyramids of Egypt, and they wanted none.

Mr. Wrightson, of Stockton, pointed out that the lead forward in bridge designing which was exemplified by the structure which was so soon to span the Forth was very remarkable, and its creation would mark an epoch in this branch of engineering. The East River bridge, in America, which joined New York to Brooklyn, approximated to it in height and span, but in that there was simply an extension of the well known suspension principle. He believed there was no cantilever bridge above half the span of that now under discussion. If the carrying out of the construction were not in the hands of those who were so well known to thoroughly understand it, the public might perhaps have doubted whether the work were possible; but, as it was, there could be no question that all promises would be fulfilled. He had gone very thoroughly into all details, and had the greatest possible confidence in the success of the plans. A point that was worthy of notice was that the contractors had carried out the erection without unduly straining the material as it was worked into the structure. The top member of the cantilever was doubtless the most difficult part to deal with in this respect, and an enormous amount of calculation had been required to work the problem out. Yet the ultimate limit of 6½ tons had never been exceeded at the end of the cantilever, for it must be remembered that, until the top member was joined to the cross supports, it was itself a cantilever.

Mr. James Riley, of the Steel Company of Scotland, next rose at the invitation of the president. He said that at first they had had a good deal of anxiety in respect to the material, but this had soon disappeared as the work went on, the more quickly, perhaps, because they had been treated with such kindness and leniency by the contractors. Not, indeed, that there had been great occasion for leniency, for he could honestly claim that their material had always stood the tests required, but he was glad to be able to acknowledge the liberal and kindly appreciation with which all their efforts to produce a steel suitable for the work had been met. Any one who was brought in contact, as the speaker had been, with Mr. Arrol, the responsible representative of the firm of contractors, could not but be struck with admiration at the resource he possessed in grappling with any difficulty. Nothing seemed to disturb him; troubles might arise, as they daily must in carrying out a work of this kind, but Mr. Arrol could always suggest a means of overcoming them; he seemed always ready

Fig. 4



THE FORTH BRIDGE.

to devise a solution for any problem, however perplexing.

The president next invited Sir Lowthian Bell, as a director of one of the contributing railway companies, to add something as to the financial aspect of the undertaking.

Sir Lowthian Bell, in response to this invitation, said that at present the financial aspect of the question was involved in obscurity; but no one, he thought, was sufficiently sanguine to suppose that the mere passage of trains across the bridge, and the fares received from passengers for that section of their journey, would afford an adequate return for the money now being expended. But there were other and wider considerations to be taken into account, and the advantages that would accrue to the lines in connection with the system of which the Forth bridge would form a link were such as would fully warrant the sinking of the money.

Mr. Adamson, in summing up the discussion, said that every one present knew he had had great experience in structures of iron and steel, and he must congratulate the members of the Iron and Steel Institute on the regularity of the mild steel of which the Forth bridge was constructed. Analysis proved that it was a material that could be depended upon, and he would indorse all that Mr. Clark had said, except upon one point. He (Mr. Adamson) considered that a man who destroyed a good steel plate by punching it deserved to be punched himself. Steel was now beyond the stage of wanting to be tested by punching, and the proper way to ascertain its qualities was by analysis. He had often told the members of the Iron and Steel Institute that silicon, phosphorus, and sulphur should be kept low in such material, and referring to the details given in the author's paper, this would be found to be borne out. He considered it wise that the strengthening elements, carbon and manganese, should be high, while the undesirable elements were kept down.

Mr. Henning said that he had been engaged in the erection of many steel structures in America, among them the East River bridge, and he wished to say, in reference to Mr. Clark's remarks, that he had always advocated drilling rather than punching holes—in fact, the former was looked on as the best practice in the United States.

Mr. Clark explained that when speaking of punching he referred to a milder steel than that used for the Forth bridge.

In replying to the discussion, Mr. Cooper said he was also of opinion that it was bad to punch holes in steel plates, and he would further add that a bad effect was produced on the material by the action of shearing. It was true that they did shear the plates used for the Forth bridge, but then they always planed the edges after, and most of the plates were delivered to the required size. As a matter of economy in working, moreover, he could not see that punching and rimering was as cheap as drilling, for they would drill five or six plates at once At times, however, when drilling overlapping parts, the drill would not go just where it ought to, and then they were obliged to have recourse to the rimer. Their experience in this respect was quite enough to teach them to avoid the use of that tool as much as possible, and they would always far rather drill at one operation than punch and rimer in two operations.

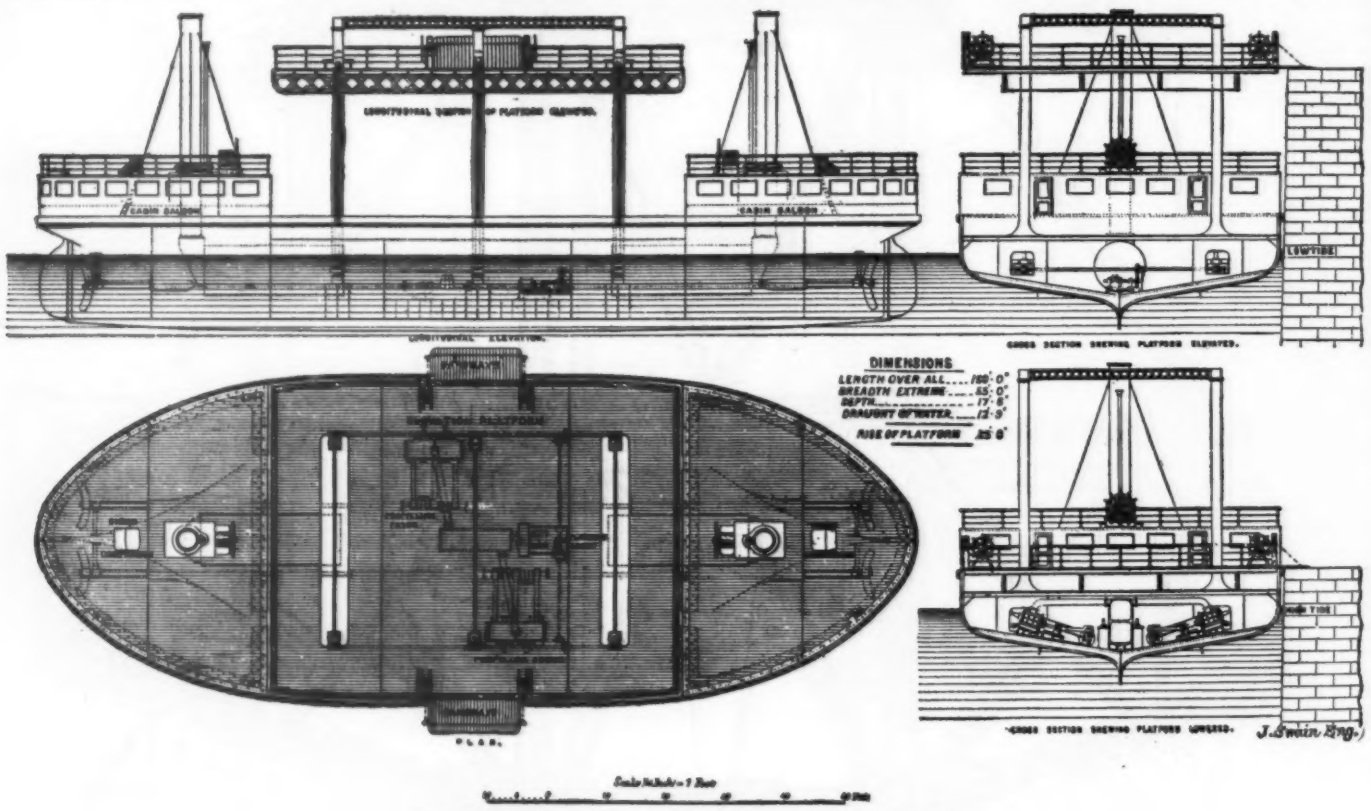
With regard to the strain, upon which a question had been asked, the speaker said that the total strain of dead load, live load, and wind was 6,000 tons; the dead load was 2,283 tons, and the live load 1,022 tons, while the wind pressure accounted for the rest. It would therefore be seen how important a factor the wind pressure was in making the calculations, and the effect of this would be seen in the design of the structure. Looking down the length of the bridge, it appeared a network of material, so that a rifle bullet could not be fired down without hitting some part. A view crosswise, was, however, quite different, for it was quite open in design, thus allowing free passage for the wind blowing up and down the river. Mr. Wrightson was quite right in saying that the great difficulty was in erecting the top member, and there was an enormous strain set up as it grew outward in the process of construction. The shearing difficulty would not be present in the finished structure, and it was got over during the building by temporarily doubling the parts most subject to strain, the extra material being removed when the member was carried out to meet the supporting parts. He had followed with interest what had been said about the material used for construction. A bridge on the same plan had been built near the Niagara Falls in America, and although commenced after the Forth bridge, it was finished first, being a smaller and more easily constructed structure. The American engineers, however, had not the same faith in mild steel that was possessed by their English brothers, and they seemed to think that steel plates were hard in one corner and soft in another, while they would tumble to pieces if one only looked at them. The Niagara bridge was therefore made of iron, and the Eiffel tower, in Paris, was made of iron for the same reason, the French engineers thinking steel not reliable. That quality, however, was exactly the one which mild steel essentially possessed. It was homogeneous; for it had the same structure or composition right through. There were no layers of soft metal with layers of slag of uncertain quantity as in wrought iron. It was ductile, too, and, in confirmation of this, the speaker exhibited several specimens and test pieces bent cold, and showing that remarkable ductility which is now recognized as a regular characteristic of the material. He had been asked whether wind pressures were greater at the top of the cantilever than lower down, in answer to which he might say there was very little difference. At Inch Garvie (the small rocky islet in the middle of the Forth which had come in so opportunely and saved such a large deal of expenditure) they had registered an average of 34 lb. to the square foot, while the wind gauges at the shore ends only recorded 12 lb. and 22 lb. respectively. This shows that the strongest blows came in puffs or flaws, and other records confirmed this; for instance, they had had 19 lb. to the square foot on the big board of their wind gauge, and 38 lb. on the small one, while from another board they had read 32 lb. On the big board there were two gauges, and the maximum register for one was 32 lb.; this was in the middle, while at the corner the maximum reading was 28 lb. It was evident, therefore, that a large structure rather than a smaller one was better able to stand against the pressure of heavy winds, for a small span might occupy the whole region of a heavy puff, while the mean pressure over a larger area would be considerably less.

Captain Jones, of the Edgar Thomson Steel Works, Pittsburg, was present, and had expressed his desire to add a few words to the discussion. The president, therefore, put it to the meeting whether the ordinary course should be departed from and Captain Jones be heard. The result was that Captain Jones was invited to speak. He said he had not designed to take part in the discussion, but he could not let what Mr. Clark had said about the practice of punching steel plates in America pass without comment. It was a point upon which he, Captain Jones, felt very strongly. Punching steel plates was a relic of barbarism, and it was but logical it should call forth barbaric remedies. There was an appropriateness about the president's suggestion to "punch a man who punched a plate," but they might find a more neutral form of treatment equally efficacious. Certainly propagation of the species of error involved in punching a steel plate should be stopped in the most effectual manner. As to the relative cost of punching and drilling, he had long since made up his mind about that, for many years ago, in constructing a roof, he had drilled all the holes, and found it cheaper than punching. With regard to the use of steel in America, they found boiler makers, bridge builders, and many others using it largely. They had started with physical tests, not chemical analysis, but they had come to the conclusion that physical tests could be met, and yet the metal not be what it should be. The test for boiler plates at the Edgar Thomson Works was higher than that demanded for the boiler plates of the United States cruisers, the limit for phosphorus being 0·035, and the manganese 0·350 per cent. He had seen steel made in America where the heat had been blown for eight minutes, the manganese being put in cold, and he was of opinion that the reaction had not taken place up to the time of speaking. With regard to steel for bridge construction, he considered that not more than 0·065 per cent. of phosphorus should be present, and the manganese should be kept low, as that was the great oxidizing agent. He would like to see these conditions enforced by law. In conclusion he wished to impress on his hearers the necessity for judging steel by chemical tests first and letting the physical tests be subsidiary to them.

Mr. James Riley asked permission to add a few words in reference to what Captain Jones had just said. He could not too strongly express his conviction that it was not the function of the engineer to say what should be the composition of the steel he had to use. That was essentially the province of the metallurgist or steel maker. The engineer might insist on any physical tests he liked, but he should not dictate how the material should be made. For this reason the speaker entirely disagreed with Captain Jones' opinion, that engineers should specify for chemical tests and consider them before physical tests in passing material.

IMPROVED ELEVATOR FERRY BOAT.

AMONG the exhibits of naval architecture at the Glasgow Exhibition, Messrs. Simons show a complete working model of their patent elevating ferry steamer, which was specially designed for passenger and vehicular traffic in Glasgow harbor. This is a most curious and interesting craft. The platform or deck may be raised or lowered until it is on the same level as the landing place. Steamers of this type are specially designed to suit the duties to be performed or the particular conditions to be fulfilled where their services are required, and the principle upon which they are constructed readily admits of such variability. When the distance to be traversed is short, as in cross river service, the deck runs fore and aft, and the exit gangways are at the bow and stern; but when the distance is great, and especially when rough water has to be encountered, the platform is athwartships, and the exits are at the sides of the vessel. Our illustration shows one of these vessels having exit platforms at the sides. Such steamers as these are peculiarly adapted for the transport of troops and artillery between the shore and war vessels lying off the land.—*The Engineer.*



IMPROVED ELEVATOR FERRY BOAT.

THE STEAM LAUNCH DEVA.

MR. ARTHUR RIGG has designed a new type of revolving engine, in which he aimed at combining the advantages of an ordinary reciprocating engine with those of a high speed rotary engine, without, however, adopting any of their faults. The latter are, in the reciprocating engine, considerable vibration at high speeds; and in those rotary engines which are free from this drawback, great wear on the moving parts, leakage, and consequent waste of steam. Mr. Rigg has applied his engine to various purposes, both as a steam and water motor, and the latest application is that of a launch engine in the steam launch Deva, which we illustrate opposite. This vessel, shown in Figs. 1, 2, and 3, is 35 ft. long over all, by 6 ft. 6 in. beam. She draws 2 ft. 2 in. aft, and is designed to steam at a speed of ten miles an hour. The boiler is of the ordinary cylindrical type, with internal flue and return tubes, and is designed for a working pressure of 120 lb. per square inch. Aft of the boiler is the engine, which we illustrate in Fig. 4 as seen from the front, and immediately behind

the engine is the steering wheel, so that one man only is required to stoke, attend to the engine, and steer. The after part of the boat is covered over by a roomy cabin, which has sleeping accommodation for two persons.

The engine has four single-acting cylinders revolving round a common stud. The outer ends of the pistons are attached by pins to the rim of a fly wheel disk, which is keyed on the propeller shaft. The centers of the disk and stud do not coincide, but are set apart by a distance equal to half the stroke of the pistons. It will thus readily be seen that as the disk revolves, the piston travels alternately out and in; and although there is a relative reciprocating movement between each cylinder and its piston, there is no absolute reciprocating movement, the only movement which can impart slight vibration to the framework being the small oscillation or pendulum action due to the eccentricity between the fly wheel disk and the stud on which the cylinders revolve. The cut-off is regulated by piston valves, which are worked by means of the two spur pinions in connection with a toothed segment and reversing lever. The engine is completely covered in, but the top cover has been removed to show some of the cylinders and the attachment of the piston rods to the fly wheel disk. The engine indicates 13 horse power with 80 lb. boiler pressure and at ⅝ cut-off. The cylinders are 6 in. diam. by 3 in. stroke, and the maximum speed is 450 revolutions per minute. The Deva was taken to Henley from Chester, passing through Staffordshire and the Black Country, and into the Thames at Oxford. The total distance traversed on this journey was about 250 miles.—*Industries.*

DYNAMO CURRENT INTERFERENCES WITH TELEPHONE SYSTEMS, AND MEANS OF RELIEF.*

By C. E. MCCLUER.

DURING my earlier telegraphic experience, I became imbued with the universally accepted belief in the theory that the earth was an immense reservoir of electricity, and that on that account, and because of its immense mass, it offered no appreciable resistance to the transmission of electrical force. Hence the universal use of the earth as a return conductor for telegraph and other electrical circuits, which are in consequence called "mixed circuits," in contradistinction to circuits composed wholly of metallic conductors. But my attention being called to the behavior of our telegraph apparatus under the influence of extraneous currents, I was finally led to question the correctness of the theory of the "infinite conductivity" of the earth.

Like nearly all of the early workers in the new field opened by Prof. A. Graham Bell's invention, I was also led into the error of attributing to "induction" nearly all the ills to which the telephone was heir.

Experience and observation, however, soon convinced me that nearly all the telephone troubles popularly supposed to arise from "induction" were the result of "leakage" only. "Induction" operating only at minute distances, while leakage would occur across wide intervals. Hence I was to some extent prepared for my subsequent experiences with the effects of electric light and electric power circuits upon telephone systems, experiences which, as I will now proceed to explain, confirmed me in my disbelief in the theory of "infinite conductivity" and the effects of "dynamic induction."

Some three or four years ago, Richmond was captured by the advance guard of the army of knights of the dynamo, to which she is now so largely tributary, and the Schuyler Electric Light Co. soon had the city ablaze with arc lights. At first we experienced little or no trouble, but after a time strange noises were heard in our exchange telephones, and as the electric light construction was extended and circuits and arc lights were multiplied, the noises increased, until they finally became a din over which it was almost impossible to project the voice. After careful consideration, I suggested certain reversals of dynamo currents, and rearrangement of the electric light metallic circuits, which were adopted by our electric light friends, greatly to our relief. But on some of our exchange wires, notably those on our Broad Street trunk line extending to the extreme western and northwestern limits of the city, the howling of the dynamo currents remained comparatively unabated. After further consideration, I became convinced that the principal source of our telephone troubles was a long electric light circuit that traversed Main Street to the western limits of the city, then crossed northward to Broad Street, which it followed eastwardly to a point opposite the power house, and thence in a southerly direction to the dynamos, thus making a loop about a mile and a half in length by a quarter mile in width. One side of this loop ran parallel with our Broad Street trunk line, almost the entire length, with only the width of the street between them. I was at first inclined to attribute to the usual scapegoat "induction" the interference which we experienced on our Broad Street wires; but my attention being about this time directed by some of my linemen to the interesting fact which they had discovered, that even in the driest weather enough of the dynamo current on this large loop escaped over the insulators and down the poles to be perceptible to the tongue when applied to a pole four or five feet from the ground, while in rainy weather a very perceptible shock could be felt by applying the hand to a wet pole, my former opinions regarding "induction" vs. "leakage," and the "infinite conductivity" of the earth, were recalled to me with redoubled force, and I soon settled down to the conviction that *leakage* was the force with which I had to deal. This conviction was strengthened by the well observed fact that the interferences from the electric light currents were greatly increased during wet weather.

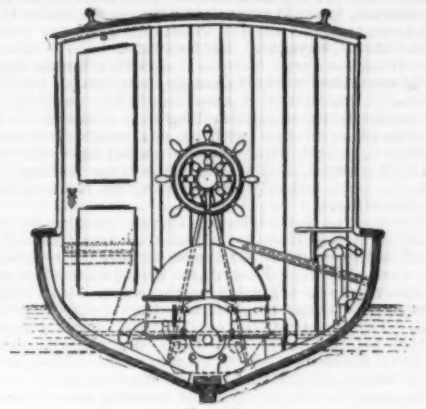


FIG. 3.

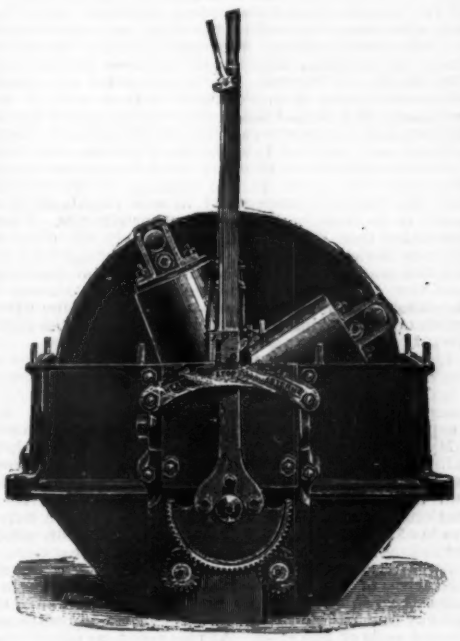


FIG. 4.

But the famous Richmond Union Passenger Railway, with its street cars propelled by electricity, became a moving, flashing reality in January of the present year, and for a time rendered the telephone business in Richmond decidedly interesting. Unlike the electric light and power systems, the electrical plant of the railway company was not designed or arranged for metallic circuits, but was, and still is, operated by mixed earth and metallic circuits, the currents being carried to the overhead trolley wires by a system of distributing mains, supported upon poles on one side of the street, these mains being connected at frequent intervals with the trolley wire by short lateral wires termed "feeders." As operated in Richmond, the electric railway system requires a double line of poles, one line on each side of the street, for the purpose of carrying short non-electric wires which extend across the street, between each pair of poles. These are termed "supporting" wires, and are designed solely to support the trolley wires at the proper height above the middle of each roadway. These supporting wires and the network of special supporting or curve wires, whose office it is to cause the trolley wires to curve parallel with the curves in the roadbed, are supposed to be insulated from the trolley and feed wires and mains, but, as we found to our cost, they were not by any means devoid of electrical currents. During the first six weeks after the inauguration of the electric road we had eight sets of telephones and one central office annunciator drop burned out by the railway currents, and about half of these accidents were due to crosses between our telephone wires and the supposed to be harmless supporting wires. While these accidents demoralized our linemen and operators to some extent, they fortunately resulted in but little damage to property and none whatever to human life, and but few of our subscribers learning of them, they created no special commotion.

But the effect of the railway system upon our central office apparatus and telephones, from the very inauguration of the railway plant to the present time, has been annoying in the extreme, and exceedingly detrimental to our exchange service. Almost the first revolution of the battery of railway dynamos tripped the annunciators of our magneto lines and rendered necessary an immediate resort to the use of special armature springs to overcome the magnetism imparted by the currents from the railway wires. Our "testing off" galvanometers were rendered inoperative, because at first the polarity of the extraneous currents was opposed to that from our galvanometer batteries, and the galvanometer needles were deflected in a direction contrary to the position assumed when under the influence of the batteries alone, the leakage from the railway wires being sufficiently strong to overcome the current from three cells of Law or Leclanche battery.

This trouble I remedied by reversing the poles of my galvanometer batteries so that they would, with the exception to be mentioned, coincide in polarity with the extraneous railway currents. And this exception, coupled with the continuous and steady nature of the extraneous currents, confirmed me in my belief that it was leakage, and not induction, from which we were suffering.

At the power house or dynamo rooms of the railway

* A paper read at the telephone convention, New York, September, 1888.

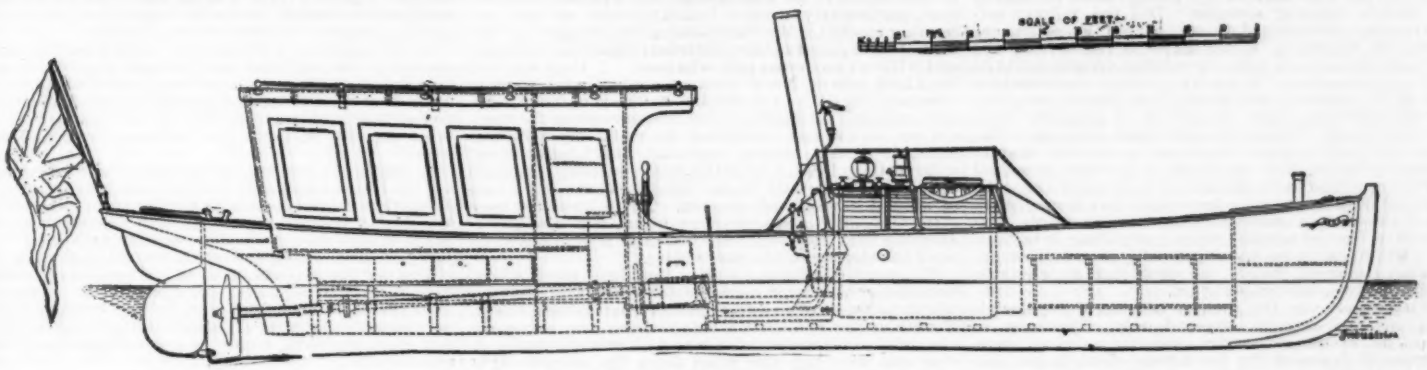


FIG. 1.—SIDE ELEVATION.

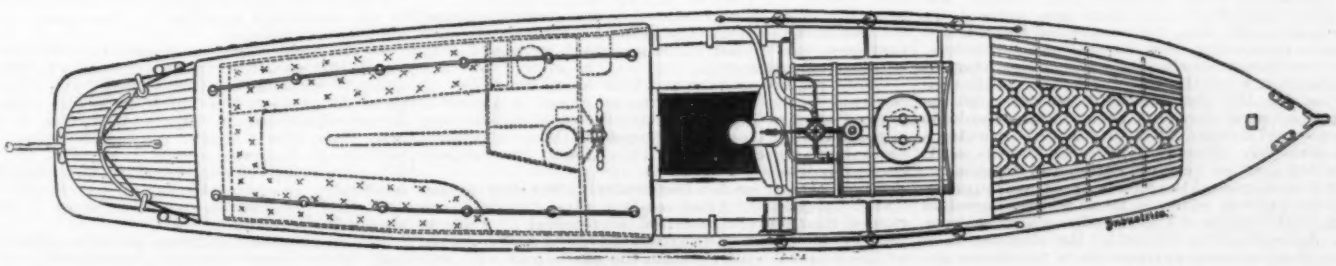


FIG. 2.—GENERAL PLAN.

THE STEAM LAUNCH DEVA.

company, distant three or four squares from our central office, the battery of five or six dynamos which furnished the current for the car propulsion was grounded; the negative electrodes being connected to several large sheets of copper at the bottom of a deep well upon the premises; the positive electrodes of the dynamos (coupled up of course in multiple arc) being connected "to air," as a telegrapher would put it, or to the distributing mains.

From all our exchange stations located in the vicinity of the dynamo rooms, within the radius of an entire block, in fact, we would therefore get a negative leakage current, while from all other stations which were grounded within a square of the railway track and wires we would obtain a positive current, thus rendering it impossible to arrange our galvanometer batteries to coincide with these leakage currents of opposite polarity.

We cannot, therefore, to-day use our galvanometers for testing off the few stations located in the immediate vicinity of the dynamo rooms. Identically the same effect was produced upon our headphone test circuits, the railway currents completely neutralizing the currents from our "test" batteries.

This difficulty was also remedied by reversing the poles of the batteries.

The exchange lines most greatly affected by the railway currents, we soon found by experience, were those which were grounded nearest to the railway tracks, irrespective of the general direction of the wires or their proximity to or distance from the railway; lines that in no place approached within less than a square of the railway wires being as greatly affected as many others that ran parallel with and in close proximity to the railway wires for long distances, but which terminated, and were consequently grounded, at points comparatively remote from the railway.

In like manner lines grounded near the heavier grades and curves of the railway, where the motor men are compelled to use the maximum amount of power in order to ascend the grades or round the curves with heavily loaded cars, are more seriously affected than lines grounded near the levels.

So clearly is this the case that our operators can readily tell from the character of the disturbance which they experience when a car is ascending a grade or when it stops or starts.

This effect of the movement of the cars you of course understand is due to the fact that the dynamo currents when propelling the cars are short-circuited from the trolley wires through motor fields and armatures to the earth, thence spreading over every available conductor in their efforts to reach the dynamos. But the maximum disturbance is experienced when three or four cars are following each other in close file, either on a grade or level. In that case the leakage due to each car traverses the contiguous telephone wires simultaneously, producing in our telephones a composite or mixed tone, each motor having its distinctive timbre or tone quality, and all united fairly making Rome—or the telephone rather—howl, and drowning out the puny currents induced by our microphone batteries.

Learning that the railway people were utilizing the municipal gas and water mains in order to re-enforce their ground connections, it occurred to me that possibly the fact of our lines being generally grounded on the gas and water pipes had much to do with our troubles. I had some of our old wires removed from these systems and connected direct to the earth through made grounds, but without altering the results.

The 450 or 500 volt currents of the railway mixed circuit system do not, however, interfere as greatly with our Richmond exchange service as the 4,000 or 5,000 volt currents carried by the metallic circuits of the electric lighting systems. Did the railway service require currents of the same E. M. F. as the arc lights, the telephone would have to retire from the field—lose ground, in fact—as metallic circuits would be their only salvation. What the railway currents lack in E. M. F., however, they make up in current strength, and are, therefore, more dangerous to property than the much more intense electric light currents. The latter will melt a fuse or burn out an arrester instantaneously, before time is given it to enter a central office or a subscriber's station and damage the telephone or outfit; while the less rapid, but larger, quantity of the railway current takes an appreciable time to melt or fuse an arrester, thus permitting it to burn out a hand-phone, an induction coil, or a bell or annunciator magnet, before the protector, of whatever kind it may be, can properly act.

In *my* experience the greater tension of the electric light currents renders them doubly disastrous to telephone exchange service, the voice being more completely drowned by the intense disturbance, due to the electric light escapage, than it is by the escaping currents from the lower tension dynamos. But the fact of the electric light being in demand, particularly the arc lights, only after business hours renders the disturbances engendered by them less noticed by subscribers generally than the weaker and less marked disturbances proceeding from the railway generators, which are continuous throughout the entire business hours of the day, when the telephone service is in constant demand. Did the arc light service continue during the hours of daylight as at night, telephone exchanges would be compelled to suspend operations or adopt the only alternative, metallic circuits, with the attendant increase in complication and expense.

Having thus discussed the effects of extraneous electric light and railway currents, let us address ourselves to a brief consideration of the remedies which we have at hand. Anti-induction devices for the elimination or exclusion of extraneous currents from telephone circuits, whether they be artificial or natural, are plentiful, but none has yet been devised that can at all compete with the old style metallic circuit.

But the metallic telephone exchange system carries with it not only a double expense for construction, maintenance, and repairs, but a vast outlay and increased complication and expense for central office plant and service, there being two line wire terminals to provide for every subscriber, and necessarily four terminals to handle for every connection, instead of two, as with the single wire and earth systems.

This great increase in wires, in complication and consequent liability to derangement, and in initial cost, and subsequent expenses for operation and maintenance, almost prohibits the adoption of the ordinary metallic system. None but the wealthy, like our long distance friends, can afford such a luxury. But there *is* a metallic circuit system within reach of even the poorest of the American Bell Co.'s lessees, a system of my own devising, and which I have found, by practical tests, to accomplish all that can be derived from an ordinary metallic circuit, and at but a tithe of the expense.

Recurring now to my theory that it was not "induction," but leakage, that annoyed us, and the expression of my disbelief in the infinite conductivity of the earth, it will readily be seen how, after arriving at those conclusions, I would very naturally reason thus: If our telephone troubles are due to leakage from the electric light and railways, and this leakage overflows into our wires from the earth *because* the earth offers an appreciable resistance to their passage, why cannot we adopt a metallic conductor of exceedingly low resistance, or of a conductivity approximating that of the earth, and use *it* in place of the earth as our return conductor, making it, in fact, what may be called an "artificial" earth or ground, and at the same time cutting loose from the earth entirely and gaining all the benefits of metallic circuits?

This idea I conceive to be in strict conformity with Ohm's law, and if only the relative resistance of the "artificial ground" or earth and the line wires attached to it were properly adjusted, we would have identically the same results achieved by the usual earth connections, and without the disadvantage of the mixed circuits. This thought revolved in my mind for some months before I could find time and opportunity to verify its truth or falsity by experiment. Besides, the device was so simple that I could scarcely conceive that it was possible that it had not already been tried and found to be impracticable, by some member of the army of electricians that had been so long engaged in efforts to solve the anti-induction problem; and it was only after conferring with some of my brother telephonists, who were favorably impressed with the idea, which was novel to them, that I took the time necessary for experiment. I, however, finally connected up several telephone circuits with a common return wire of low resistance, and found that conversations could be carried on, and a magneto call bell rung on each circuit without any mutual interference whatever, and it required a resistance of 35 ohms by galvanometer measurement to be added to the common return wire before the currents propagated in one circuit could be heard in the telephones on the other circuits. I thus concluded that there was approximately 350 ohms resistance in each circuit, due to the conducting wire, the call bell magnets, and the hand-phones and transmitters, that the "artificial ground" wire should bear to the other side of each circuit the direct or line wire a resistance approximating one tenth that of the entire circuit.

Encouraged by this experiment, and anxious to do something to improve the night service of my exchange, I laid my scheme before the executive officers of my company, and was furnished with a half mile of No. 4 copper wire with which to make some practical tests.

My first experiment was with our No. 19 northern call wire and its connecting lines. This was our shortest call wire, being only a third of a mile in length, and had connected with it some 18 or 20 subscribers' stations, located in close proximity to the 7th Street grade of the electric railway, an 8 or 10 per cent. grade, extending from Franklin to Grace Street, one square.

At the corner of 7th and Franklin Streets, the main feed wires of the railway plant, direct from the power house, two squares distant, first touched the line of the railway and divided right and left to the opposite and distant ends of the road. At this point, as might have been anticipated, and on our telephone lines grounded in this vicinity, we experienced the greatest interference, particularly when a heavily loaded car was ascending the hill. My "artificial ground" gave us immediate and remarkable relief from the railway leakage, and without any cross talk whatever. I then applied for a half mile of No. 6 covered copper wire, which I connected to the end of the first half mile of No. 4 wire, and extended artificial ground wire on out to the western end of the city, intending to make my next test with one of our longest taps and our longest lines, with stations located near the most westerly extension of the long Main and Broad Streets electric light loop of which I have already spoken. These lines had been almost entirely abandoned at night, our subscribers averring that they could not use their telephones at all after the electric lights were ablaze.

The worst of all was a station in a drug store, whose proprietor had long made bitter complaint that his telephones were of no service to him whatever after dark. Yet when the change was made from the natural to the artificial ground at this and all other stations on that call wire tap, the relief from the electric light leakage was as instantaneous and marked as that experienced from the railway leakage on short tap No. 19. In fact, such was the change wrought on these wires that it was possible to carry on a whispered conversation over lines connected to my artificial ground that when connected to the natural earth were so noisy that even the loudest shouting could be heard only with extreme difficulty.

While cogitating over my idea in its incipiency, it occurred to me that even the adoption of a *general ground wire* of high conductivity would relieve our telephone wires from the influence of these extraneous currents, to a great extent. This I found from experience to be true.

When arranging for the central office end of my "artificial ground," I had made a plug switch so arranged that, by the insertion or removal of a single plug, I could connect the artificial ground wire to earth, or disconnect it entirely from the earth, and with one motion connect it, with all of its attached wires, into a "compound metallic circuit system."

I could thus readily note the difference made by the use of the large copper wire as a *general ground wire* or as a substitute for the earth. In the one case, as you understand, if I have made the matter clear to you, the large copper wire was connected to earth at only one point through the plug switch in the central office, while in the other it was disconnected from the earth entirely.

To those familiar with the details of a telephone exchange it will be clear that some such provision for grounding or connecting artificial grounds to Mother Earth is essential, as long as any of the wires of the system remain in connection therewith, because of the necessity of connecting stations not yet changed to the artificial ground to those that have been thus changed, otherwise the one will be grounded and the other "dead open," and consequently inoperative.

In this way I found by experiment that, when the large copper conductor was to earth at the central office, and being used simply as a general ground wire, the electric light and street railway interferences were reduced about 50 per cent.; and when used wholly detached from, and wholly in place of the earth, they were reduced the other 50 per cent., or eliminated entirely.

By thus utilizing the large conductor, *first*, as a general ground wire to carry the microphone and signaling currents to the earth at the central office, or at any other locality remote from the offending electric light or railway plant, an exchange system can be gradually converted from a mixed metal and earth system into a compound metallic circuit system throughout, without any interference whatever with the service of the exchange, and to its manifest improvement during the time the change is being made. And when the last subscriber's line has been transferred from the natural to the artificial earth at the last station, it is only necessary to withdraw the solitary plug that still connects the system to the earth, and, presto! you have an exchange of purely and practically metallic circuits alone, with all of the advantages and without any of the disadvantages of the ordinary metallic circuit systems; the one series of large copper wires extending out on the various trunk lines, but all united in one at the central office, answering fully the purposes gained by the ordinary duplication of each individual wire, and necessitating no change whatever in either central office or station outfits or appliances, beyond the simple substitution of the artificial for the natural ground.

In practice it may be found that a greater proportion than one tenth the resistance of any one circuit may safely be given to the artificial ground wire, but my experience and experiments lead me to believe that it will be far safer and more satisfactory to keep the resistance of the artificial ground to one twentieth that of the entire circuit.

In an exchange the size of our Richmond exchange I advocate the use for each individual trunk route of a single copper conductor composed of a half mile each of No. 4 and No. 6 wire, with No. 8 for lateral lines and the remaining distance to the farthest stations, with No. 14 to stretch from the poles into the stations. All of these wires should be of hard-drawn copper with a good covering, and strung on the same poles and fixtures that carry the regular exchange wires, but insulated carefully both from them and the earth. And I should place these artificial ground wires at the lowest point on the poles, or the least distance from the sidewalk or ground, beneath all of the line wires if possible.

In this position the small amount of leakage currents that are attracted up the poles from the earth, whether from electric light, electric railway and power circuits, or earth currents, will be intercepted by the large copper wires and by them carried to those points in the system where they will escape to earth again, without any adverse influence upon telephone wires proper.

While, in the absence of any direct experiments, I cannot say positively that such will be the case, I however believe that if our long distance friends will couple together so as to make of some eight or ten of their No. 12 or 14 copper wires practically a single low resistance conductor, they will find that this compound conductor will answer as an artificial earth or return wire for treble or quadruple the number of wires thus coupled together, while a single conductor of the same conductivity would double the capacity of their poles and the number of their metallic circuits.

In like manner, I believe the same principle can be applied to telegraph and electric light or power circuits, relieving them from the disturbing and damaging influences of earth currents and atmospheric electricity and conferring upon them all the advantages of metallic circuits without the ordinary duplication of wires.

In conclusion allow me to say that while I flatter myself that I am charitably disposed, and ever inclined to do all that within me lies to further the interests of the telephonic fraternity and increase the efficiency and value of our telephone service, I do not think I am justified in assuming the role of public benefactor, and giving my device away, even in the interests of science. Believing it to be novel, practicable, and valuable, I have therefore conceived it to be my duty, as well as privilege, to apply for a patent, and my application is now pending, with, I trust, a good chance for a favorable decision.

SPECIFICATION OF WIRING.

THE following is for a proposed electrical installation in the buildings occupied by Hampton & Sons, Pall Mall East, London.

By the term wiring is meant the whole of the materials and work for a thoroughly perfect electric installation of incandescent lamps erected and fitted up complete in or upon the buildings in the occupancy of Messrs Hampton & Sons, namely, Nos. 8, 9, 10 Pall Mall East, Nos. 1 and 2 Whitcombe street, and the building in Monmouth court, London, S. W., with the following exceptions only, namely, no electrical or other machinery, or any apparatus for generating or storing electricity, or any converter, or work in connection therewith, is included.

The whole of the buildings are to be lighted throughout. There must be no interference with the existing gas lighting without permission.

The tender must be in four separate portions, as set forth in the accompanying schedule.

The parties tendering must supply a schedule and plan describing the manner in which they propose to light each shop, show room, office, passage, corridor, staircase, or other part of each building. The number of lights must be stated, their individual candle power, how arranged, what fittings it is proposed to supply, and their make and design. The method of arranging the conductors, and full details of how they propose to place the whole installation.

No existing chandeliers or gas fittings are to be utilized.

There are to be no combination fittings.

The tender must be for a thoroughly complete and perfect installation for each building, down to the smallest details. It must include the cost of all cutting and making good again, and the contractor is to provide all necessary implements, scaffolding, and apparatus, and a sufficient number of skilled workmen and laborers for the proper, expeditious, and complete execution of the works and cleaning up and removal of waste materials. And he is to supply any workmanship, materials, and labor which, although not specially named in this specification, may be, nevertheless, incidentally necessary for the proper and expeditious completion of the work described therein. And the contractor is to make good again at his own cost any damage or destruction that may occur to the works, whether by accident or any other cause whatsoever, until the installation is completed.

The contractor is also to be responsible for any damage or injury done to the buildings or to the property belonging to Messrs. Hampton & Sons that may be occasioned by the act of any of those in his employment (any property held in trust is to be considered for this purpose as the property of Messrs. Hampton & Sons).

The business carried on in the premises is not to be interfered with in any way during the progress of the work. No work is to be commenced after 10 a. m. or carried on before 6 p. m. without permission in writing.

All materials and work are to be of the very highest character and excellence.

The contractor must keep the entire installation in thorough working order and repair, at his own expense, for a period of 12 calendar months from its completion, renewal of worn-out lamps excepted.

No extra, additional, or different work will be allowed for under any circumstances whatsoever, unless an order for the same be given and signed by Mr. Musgrave Heaphy (acting for Messrs. Hampton & Sons), specifying that it is for extra or altered work.

Should Messrs. Hampton & Sons (or their representative) desire the position of any light or lights to be altered from what had previously been arranged, either before or during the progress of the work, this is to be done without any extra charge, provided it does not necessitate any work that has been placed up being done over again.

All work and materials and the entire installation in each building are to be subjected to the approval of Mr. Heaphy (acting as aforesaid), and he is to have the power of rejecting any work or materials he is not perfectly satisfied with.

All insulation tests must be to his complete satisfaction. They must be extremely high, especially with regard to earth.

If, however, from hidden or from any other causes whatsoever, within the said period of twelve calendar months, it be found that the installation, or any part of it, in any of the buildings is not working efficiently, then it shall be in the power of Mr. Heaphy to refuse to pass such part of the whole of the aforesaid installation until it has been altered and arranged to work efficiently and to his entire satisfaction, and this notwithstanding that the materials, work, and arrangement had previously met with his sanction and approval.

The whole of the work of each tender must be finished within the time specified in schedule for each portion of the work after the order to proceed with the work has been given, under a penalty of two guineas per day for each day after that date the installation is incomplete, unless a certificate be given by Mr. Heaphy stating that such delay arose from circumstances reasonably beyond the control of the contractor.

If, in the judgment of Mr. Heaphy, the work is improperly conducted or sufficient dispatch is not used about it, Messrs. Hampton & Sons shall have the power, upon giving to or leaving at the last known place of residence or business of the contractor six days' notice in writing, to dismiss him and his workmen from the works either wholly or in part, and to appoint other persons, contractors, workmen, or laborers, who shall supply, either by day work or otherwise, the requisite labor, workmanship, materials, means, and appliances for the due execution and completion of the contract; and the costs and charges incurred by them, or any of them, in so doing shall be ascertained by Messrs. Hampton & Sons, and paid for or allowed to Messrs. Hampton & Sons by the contractor; and it shall be competent for Messrs. Hampton & Sons to deduct the amount of such costs and charges out of any money due, or to become due, from them to the contractor.

Payment on account of 80 per cent. of the contract price will be paid within one week of receiving a certificate from Mr. Heaphy that the whole of the work is complete and to his satisfaction. The balance will be paid at the end of twelve calendar months; provided the installation is then in a thoroughly good and efficient condition, free from any defects arising from any bad workmanship, materials, or from any other cause whatsoever.

In the event of any lawsuit or injunction being brought against Messrs. Hampton & Sons, for using any part or parts of the installation placed up by the contractor, then the contractor shall indemnify Messrs. Hampton & Sons for any loss or expense they may have been put to in the matter, that is to say, if such lawsuit or injunction arises out of alleged infringement of patents only.

The lamps to be used must be Edison-Swan of 100 volts, and 16 or 18 c. p. (nominal) each.

No lamps are to be considered as less than 16 c. p. (nominal) each, so far as the conductors are concerned.

The lamps must be arranged in simple parallel.

The lighting of the show rooms and windows must be *brilliant*.

The lights in the various buildings are to be all single, either suspended from the ceilings or fixtures on the cornices, walls, or other portions of the buildings, as may be determined upon by Messrs. Hampton & Sons.

The position of all lights must be such as meets the approval of Messrs. Hampton & Sons.

Should Messrs. Hampton & Sons, or their representative, desire the position of any light, or lights, to be altered from what had previously been arranged, either before or during the progress of the work, this is to be done without any extra charge, provided it does not necessitate any work that has been placed up being done over again.

The arrangement of the wiring, wherever practicable, must be as follows:

The conductors from the converters must be brought to main switch board in the converter house (or other position that may be determined). From this switch board main circuits are to come into the buildings and be brought to distributing switch boards, and there split up into small branch circuits, carrying not more than five amperes. Where a main circuit cannot conveniently be brought to a distributing switch board, then it must be divided into sub-mains, or branches, which must be so brought to distributing switch boards.

The number of main circuits proposed must be stated in the tender.

The wiring must be so arranged that no show room will be dependent upon one main circuit.

All work *must be surface*, except where permission to the contrary from Mr. Heaphy is given. In the event of any work being placed between floors and ceilings, special precautions against fire, as directed by Mr. Heaphy, must be taken.

The switch boards must be of an approved incombustible and non-conducting material (if slate be used, care must be taken that it is of a non-conducting quality). The switch boards must be furnished with a switch and cut-out for every conductor.

The distributing switch boards must be mounted on oak or teak, and have glass cases furnished with lock and keys all to pass.

The utmost care must be taken with regard to the design and arrangement of all work in connection with them, and drawings must accompany the tenders. The tenders must also state the number it is proposed to place in their positions, and the number of circuits it is proposed to lead from each.

The wiring must be so arranged that it will be equally suitable to be utilized whether the electricity be generated on the premises or supplied from the London Electric Supply Corporation by their system of high tension primary currents and converters (the E. M. F. of the secondary current being 100 volts), or from any other source. No portion of the primary work is to be included in the tender, but the tender is to include the cables from the main switch board to the converters, the positions for which will be pointed out on the spot.

The arrangement of the wiring must be such that lamps of the same nominal candle power will be equally brilliant in all parts of the buildings mentioned in the schedule when the electricity is on. The whole responsibility of this must rest on the contractor.

The contractor must also produce a certificate from the London Electric Supply Corporation, stating that the installation is thoroughly suitable and efficient so far as their system is concerned. This certificate must be produced before any payment will be made to the contractor.

All conductors must be composed of copper of at least 98 per cent. conductivity.

All conductors must be composed of strands.

No conductor is to be of less size than the equivalent of No. 18 B. W. G., unles permission is given.

All conductors are to be insulated in the highest manner, with very thick India rubber of the best quality, and they are to have substantial coverings of braided hemp. Samples of the kind and quality required can be seen.

No conductor is to carry more current than 150 amperes.

No conductor is to carry more current than the proportion of 500 amperes per square inch of section in the case of the mains and principal branches; nor more than the proportion of 750 amperes per square inch of section in the case of the smaller branches or wires.

No twin wires are to be used, except in those cases where permission has first been given. They must be of special make.

The conductors in the converter room must be bedded in the walls (well apart) or placed in fireproof casings, as may be determined by Mr. Musgrave Heaphy.

The position of all conductors must be indicated by a distinguishing mark in those instances where the conductors are hidden out of sight.

There is to be no bunching at the positives together, or the negatives together, without permission.

All conductors are to be incased in substantial, hard, well-seasoned wood casing. The positives and negatives must be placed in separate grooves, and where required filled in with silicate cotton, or asbestos, or other approved putty. The width of wood between the grooves should not be less than two inches in the case of the mains, one inch in that of the principal branches, and three-quarter inch in that of the smallest branches.

The covers of the wood casing should be screwed on, and the width of the sides of the casing should be amply sufficient to allow of screws being driven in when required.

All wood casing must be treated with an approved fireproof paint or compound. Reference must be made to Mr. Heaphy as to the treatment the wood casing should receive and the paint or compound to be used. The casing should be composed of the wood known as "American whitewood."

All wood casing where required to be of such ornamental character as to meet the approval of Messrs. Hampton & Sons.

All joints must be thoroughly well made and soldered, and most carefully insulated. Specimens showing how the joints are to be made and insulated can be seen.

Cut-outs are to be placed upon all conductors down to the very smallest. Every change of section must be protected by its own separate cut-out. Single cut-outs may be used for single lights, except where they are taken directly off a main, or main branch, in which case a cut-out must be placed on each conductor.

All cut-outs must be in incombustible boxes, and none are to be placed under floors, or otherwise hidden out of sight, except in those instances in which special permission is given to the contrary.

The connections of the cut-out should be soldered where practicable.

All cut-outs must meet the approval of Mr. Musgrave Heaphy, to whom samples must be sent before any work is commenced, and who should be consulted on the matter previous to the tenders being sent in.

All lamp holders must be of an approved type, and as incombustible as possible.

All switches must be of the best possible make and design, and such that they will not be able to rest in any intermediate position between full on and off. Samples must accompany the tender.

All switches must be mounted on slate or other approved incombustible material, and when not on the switch boards must have behind the slate an oak or teak backing.

In many cases, individual lights must have switches. These may be single pole.

A sketch must accompany the tender, showing how the whole of the work is to be arranged.

A sketch, showing the make and design of each fitting it is proposed to supply, must accompany the tender.

All work in connection with these must be of a specially secure character.

All ceiling roses used must be of a specially secure character, and samples must accompany the tender.

The tender must state the character of the shades it is intended to supply. Samples must be sent.

Sufficient incandescent lamps for each portion of the whole installation, together with 50 extra ones, are to be supplied.

After the work is completed, one copy of plans, properly drawn, colored, and framed and glazed, showing the position of the work in every portion of the buildings, must be supplied by the contractor free of cost.

The position of all work, down to the smallest detail, must be such as meets the approval of Mr. Heaphy, and no work is to be commenced in any portion of the buildings without previous consultation with him and with his permission.

The greatest possible care must be taken that the decorations in the rooms, passages, corridors, and other portions of the buildings are not injured, and that the work, as much as possible, harmonizes with them.

With regard to fire risk, the whole of the work must comply with the Phœnix Fire Office rules (thirteenth edition), and must be to the satisfaction of Mr. Musgrave Heaphy, and his approval must be obtained before any payment will be made to the contractor. It would be preferable if he were consulted before any tender was sent in.

In the event of any dispute or question arising between the contractor and Messrs. Hampton & Sons (or their representative) on any matter whatsoever connected with the work or the interpretation or meaning of any part or the whole of this specification, at any time during the progress of the work or after the work has been completed, or after the before-mentioned twelve months has expired, then such question or dispute shall be referred to Mr. Musgrave Heaphy to arbitrate upon and decide, and his decision shall be accepted as final and conclusive on both parties.

A schedule of prices for any extra lights (including portable lights) or work that may be required must accompany the tender. A separate sum must also be stated with regard to the cutting away and making good again, and also for the wood casing (not fixed up).

Messrs. Hampton & Sons do not bind themselves to accept the lowest or any tender. They may accept any one or more of the four portions of the tender to the exclusion of the rest. The parties tendering must do so at their own expense.

A separate tender may be sent in, stating at what price per annum the whole installation would be kept in thorough working order and repair after the expiration of twelve months mentioned in this specification.

METHOD OF DEPOSITING THE HEAVY METALS.

THAT what are known to metallurgists as the heavy metals might be of considerable use in the arts, if a cheap method of depositing them by the electrolytic process could be devised, has been well known to students, and it is possible that the improvements by Prof. S. P. Thompson may be of commercial importance. His improvements relate mainly to the electrodeposition of the heavy metals, such as platinum, iridium, palladium, ruthenium, and the like, and of their alloys, and have for their object the obtaining of the deposits in a bright metallic form, also of cheapening the preparation of the solution for producing such deposits. The metal or alloy is first brought to the state of chloride by known chemical processes. The chloride, after having been dried at a moderate temperature, preferably that of steam, is dissolved in distilled water or other soft water of adequate purity. To this solution is added a solution of a certain medium, also previously similarly dissolved, the weight of the medium taken being from 10 to 40 or 50 times as great as that of the metallic chloride. As mediums are employed phosphate of soda, or phosphate of soda mixed with borate of soda or carbonate of soda, or with tungstate of soda, or with any of these materials, or the corresponding salt of ammonia mixed with the soda salt. The mixed solutions of metallic salt and medium are then heated together, preferably to the boiling point; and to the liquor so produced is added one of the following brightening substances—namely, sal ammoniac, bromide of soda, carbonate of soda, bicarbonate of soda, carbonate of ammonia, hyposulphite of soda, hypochlorite of soda, chlorate of soda, or a mixture of two or more of them, for example, a mixture of sal ammoniac and carbonate of soda. Preferably such brightening substances are also similarly dissolved in a little water previously to being added to the solution. The mixture having then been preferably once more heated, it must be neutralized. If it is found alkaline, a few drops of hydrochloric acid or a solution of chlorine in water or other suitable substance are cautiously added. If it is found acid, carbonate or bicarbonate of soda is added.

The bath so prepared should be warmed to a temperature of from 60° to 90° C. (140° to 194° Fahr.), and is used in the ordinary well known way, with a fairly strong electric current. The anode may be of carbon or of platinum; but in every case it will be found requisite in the daily use of the bath to add (preferably hot) further quantities of strong neutral metallic solution as the metal is withdrawn by deposition from the bath, and also from day to day to add small quantities of borate of soda or other medium, and also of carbonate of soda or of hydrochloric acid or chlorine water to correct the acidity or alkalinity of the bath. As a typical example

of the improved process, the following quantities may be taken for the deposition of bright metallic platinum—viz., chloride of platinum 2 oz., borate of soda 1 lb., carbonate of soda 1 lb., sal ammoniac 2 oz., the solution being finally made up with water to 1 gallon. Owing to the costly nature of the separated chlorides of the single metals, such as chloride of iridium and chloride of platinum, the patentee prefers to employ a mixed metallic chloride containing platinum with a certain admixture of iridium, ruthenium, or the like, just as it occurs in or is derived from the natural ore. Grains of the natural ore are treated with hot aqua regia to obtain the chlorides in solution, these being subsequently boiled down to expel nitric acid. Or the mixed solution may be prepared wholly or in part by electrolysis, the grains being placed on a plate of carbon or other suitable anode, and subjected in a chloride bath to the action of a current which slowly dissolves out the more soluble part of the ore. The residue may be afterward further digested in aqua regia. Prof. Thompson is aware that phosphate of soda and phosphate of ammonia, and also chloride of sodium, in conjunction with chloride of platinum, have already been suggested for use in baths for the electro-deposition of the heavy metals, and he therefore lays no claim to the use of such substances in themselves, but only their use in combination with the other substances and in the manner described.

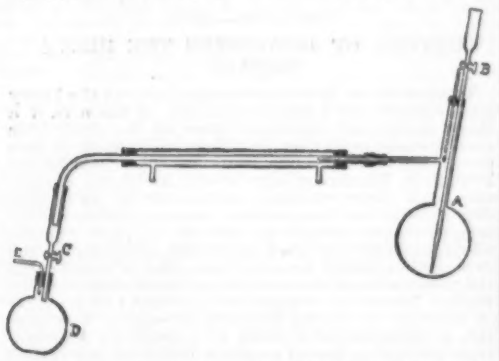
APPARATUS FOR FRACTIONAL DISTILLATION IN VACUUM.

By SPENCER B. NEWBURY.

THE subject of distillation under reduced pressure has been thoroughly discussed by Anschütz,* and the apparatus recommended in that author's pamphlet certainly appears to leave little to be desired in respect of convenience or efficiency. The arrangement shown in the accompanying figure has, however, the advantage that none of its parts requires to be specially constructed, and the whole may easily be put together from apparatus to be found in almost any laboratory.

A distilling bulb, A, is provided with a double-bored rubber stopper, through one aperture of which passes a thermometer, and through the other the tube of an ordinary separating funnel, drawn out at its lower end to a capillary tube which reaches nearly to the bottom of the flask. The outlet tube of the bulb is connected with a condenser, as shown in the sketch. The inner tube of the condenser is bent down at its lower end and terminates in a second separating funnel, the tube of which passes into the receiver, D; from the latter a small bent tube, E, serves to connect the apparatus with an ordinary Bunsen filter pump provided with a manometer.

The substance to be distilled is placed in A, the air exhausted to constant pressure, and the distillation commenced by heating A in a bath of water or paraffine. A gentle current of air is allowed to bubble through the liquid by slightly opening the stop cock, B. This may be so slight as to have no effect on the pressure, and serves to prevent the "bumping" of the liquid. As soon as one fraction has been collected in the receiver the stop cock, C, is closed, air is admitted through E, and the flask, D, removed and replaced by another. This is then emptied of air, the stop cock, C, opened, and a second fraction collected. In this manner a series of fractions may be obtained without the necessity of admitting air to the whole apparatus



when the receiver is changed. (This is essentially the arrangement described by Thörner.†)

The separating funnel, B, serves not only as an inlet tube for air, but also for the introduction of the successive fractions for redistillation without loss of vacuum. By the use of this simple device, complete fractional distillation may be effected almost as rapidly and uninterruptedly as under ordinary pressure.—*American Chemical Journal.*

* Ueber die Destillation unter vermindertem Druck, Bonn, 1887.

† Ber. d. chem. Ges. 19, R. 407.

THE SPECIFIC GRAVITY OF GAS.

VARIOUS plans have been followed in determining the specific gravity and composition of gas; and as a rule we are as a body slow to adopt a new system unless there is *prima facie* evidence of its ultimate success. How many valuable patents have fallen through simply for want of capital or lack of energy? and how many valuable ideas have been formulated in the brains of mechanicians who have never benefited one shilling thereby? There are lyrics now in existence which were rejected some years ago, but afterward found favor in the eyes of a less flippant critic, and led to fame and fortune. And in mechanics and science there are doubtless many tales of ideas worked out and "improved" by friends or neighbors, it may be, with wit enough to perceive the weak point and build thereon. But we have not to deal with an old patent or appliance, but simply to consider an ingenious application of the principle upon which the common lever balance is constructed, resulting in the production of an apparatus for automatic determination of the specific gravity and composition of gas. Hitherto four methods have been followed for this purpose, to which allusion must be made, as there was little time at the Glasgow meeting to give that attention to the subject which it really deserves.

All the systems now adopted at home and abroad require time and skill on the part of the operator, and it was to obviate this defect that Herr Lux introduced his gas balance to the attention of gas engineers. In the direct method of weighing gas, a hollow vessel is weighed by means of a sensitive scale—first in an exhausted state, then when filled with air, and lastly when filled with the gas to be examined. The specific gravity is obtained by dividing the weight of the air by that of gas. This method was, however, simplified by Dr. Letheby, and in using his apparatus we have simply to expel the air by the inflowing gas and take the weight. In Wright's aerostatic method, a balloon of fixed capacity is filled with gas, and a saucer suspended from the balloon is loaded until the tendency of the balloon to rise is neutralized. The difference between the weights represented by the balloon, the saucer, and its contents, and the weight of the air displaced by the balloon, represents the weight of the gas. This result divided by the weight of the air displaced gives the specific gravity.

Bunsen's effusion test is based on the principle that if gases are expelled under the same pressure through a small aperture of minute thickness, the squares of the velocity of expulsion are in inverse ratio to the specific gravity of the gases. This plan has been further developed by Schilling and Bowditch, who have made the apparatus accessible to all interested in the manufacture of lighting gas. Recknagel's test is based upon the principle of communicating tubes, according to which the heights of two columns of liquids are to each other in inverse ratio to their specific weights.

However excellent these methods may be in the hands of a skilled operator, we have before us an apparatus by which "the specific gravity of gas may be ascertained in the same automatic way in which it is possible to ascertain temperature and pressure by means of the thermometer and the barometer, and the specific weight of liquids by the hydrometer." Herr Lux has solved the problem by following the principle on which the ordinary lever balance is made, and the simplicity of the apparatus will be perceived on examining the accompanying illustrations. The pillar in the diagrams (1 and 2), which is fixed to a solid plat-

FIG. 1.

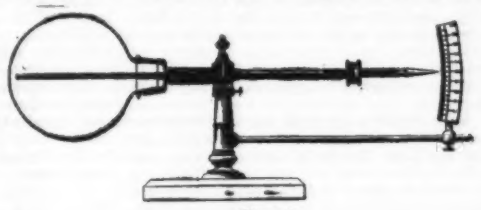


FIG. 2.

form, is divided at its upper extremity into two branches like a fork. These branches have conically depressed steel saucers, upon which the beam rests by means of steel points. The beam—explains the inventor—consists of a central body, to one end of which is fixed a hollow globe (made of glass or metal), while the other terminates in a tongue, and is provided with a counter weight. From the upper extremity of the central body two narrow tubes are seen to issue at right angles, one of which enters the tube which constitutes the continuation of the beam of the balance inside the globe, while the other enters the globe directly through the annular orifice in the central body. These two tubes are bent at their outer ends at right angles in a downward direction, and terminate in small saucers, which, being filled with mercury, constitute an effectual hermetic seal. The solvent action of the mercury is counteracted by the ends of the tubes and also the saucers being made of ivory. Through the mercury a small tube enters from below into each of the saucers, and terminates in a joint piece. The gas enters through one of the India rubber tubes, one of the saucers, and one of the angular tubes into the globe, passes through it systematically, leaves the globe through the tube at the other end, and finally passes through the second angular tube, mercury saucer, and the second flexible tube. Through both the inlet and the outlet tubes for the gas there are made to pass hermetically two adjusting screws, the points of which, resting in the conically depressed steel saucers, constitute the pivots of the system. By turning these screws, the center of gravity of the balance may be fixed at a longer or shorter distance from the center of motion, and thus we can at will lessen or increase the sensitiveness of the instrument. The arched scale, fixed by means of a coupling rod to the standard of the balance, is furnished with a division suiting the requirements of any special case—from 0 to 1 for apparatus intended for the determination of the specific gravity of lighting gas—and the extremity of the tongue moves in close proximity to the scale, by which the reading of the specific gravity of the gas under examination is made easy.

The working of the apparatus is exceedingly simple. If the beam takes a definite position when the globe is filled with atmospheric air, that portion which carries the globe will go up or down, as a lighter or heavier gas is introduced. In adjusting the apparatus, the counterweight is so placed that when the globe is filled with ordinary air, the tongue may be exactly at 1, which indicates the specific gravity of the air. The globe is filled with pure hydrogen, and the point indicated upon the scale marked 0·07. Afterward the upper section of the scale is divided into 93, the lower into 7 equal parts. Messrs. Alex. Wright & Co., of Westminster (who are the British agents), are of opinion that this ingenious apparatus will be found exceedingly useful by gas engineers and chemists in ascertaining the quantities of carbonic acid in illuminating gas, as well as in the saturation gases of sugar refineries in heating, generator, and smoke gas, and also in determining the quantities of moisture and of carbonic acid in the atmosphere.

Indeed, it is possible to ascertain quantitatively two or more of the constituents in the composition of mixed gases: for example, the carbonic acid and carbonic oxide contained in fire gases and in those which come from blast furnaces. The gas balance will enable engineers to study several points in the destructive distillation of coal, wood, and mineral oils in the manufacture of gas, in the combustion and explosion of gases in gas motors, and in the diffusion of gases in air balloons, in a thorough and satisfactory manner. Many points in the process of gas making have up to the present been obscure, but with the gas balance in the laboratory Herr Lux is decidedly of opinion that these obscurities "may in the near future emerge into the light of certainty."

For the purpose of determining the specific gravity of illuminating gas, the English agents are constructing the balance in two forms, of which Fig. 3 is provided

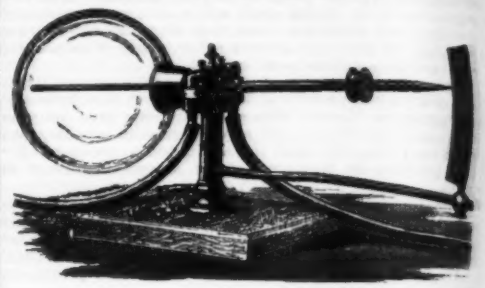


FIG. 3.

with a gas supply and a discharge pipe. By means of this contrivance the gas which has been examined can be carried farther—as, for instance, to the photometer; while in the second form the gas escapes through a vertical tube provided at the extremity with a burner, and is there consumed. Strange to say, "the radiating heat of the flame of an apparatus which consumes about two cubic feet of gas per hour exercises absolutely no appreciable influence on the gas in the globe."

It may be as well to remark that the apparatus is very sensitive. When the balance is brought from a cold into a warm room, or *vice versa*, the temperature of the air contained in the globe must be adjusted to that of the surrounding air, as otherwise differences may result, amounting to several degrees on the division scale. In examining crude gas, which may contain particles of tar or ammoniacal liquor, a vessel filled with a good filtering substance, like wadding, asbestos, or glass wool, should be inserted in front of the balance.—*Gas Engineer's Magazine.*

A PROCESS FOR SEPARATING AND DETERMINING ZINC.

By J. RIBAN.

THE accurate determination of zinc in the moist way presents, as it is well known, great difficulties. The precipitation by means of ammonium hydrosulphate requires a settlement of from twelve to twenty-four hours; the filtration is discouragingly tedious, and we are compelled to load the mother liquid and the washing waters with ammoniacal salts to prevent the precipitate from passing through the filter.

If we effect the precipitation in an acetic solution by means of sulphureted hydrogen, the sulphide obtained is still gelatinous, and presents similar inconveniences, though in a less degree. The precipitation of zinc by means of sodium carbonate is often incomplete, and the flocculent precipitate carries down considerable quantities of alkali, which cannot be completely eliminated by washing. Moreover, this method cannot be applied in presence of the alkaline earthy bases, and only permits the separation of zinc from the alkalies.

The author has arrived at a process which is free from these defects. It consists in transforming the zinc salt into a soluble hyposulphate by the addition of an alkaline or earthy hyposulphate and treating it *in the cold* with sulphureted hydrogen. There is formed a pure amorphous zinc sulphide, so dense that it soon collects at the bottom of the liquid, while the supernatant liquid remains clear, notwithstanding the movement produced by the gaseous current. As this precipitate is formed dithionic acid is set free, but its action upon zinc sulphide is very slight, and even null in dilute solutions, so that at certain degrees of dilution the process is at once expeditious and very accurate. The precipitate may be separated from the supernatant liquid by simple decantation, and can then be easily washed by continued decantation and filtration. The liquid containing the salt of zinc is saturated with sodium carbonate until a permanent precipitate appears, and is then redissolved by a few drops of dilute hydrochloric acid. To this slightly acid liquid there is added an excess of sodium or barium hyposulphate, more than sufficient to effect the double decomposition with the salt of zinc and the free acid; an excess of the hyposulphate does no harm. The liquid is diluted with water so that it may contain, at most, 0·1 grm. zinc in 100 c. c. There is then passed into it a current of sulphureted hydrogen in the cold. The precipitate of zinc sulphide, quite white and very heavy, collects quickly. After letting settle for a few minutes the limpid liquid is decanted carefully through a filter. Upon the precipitate is poured boiling water and sulphureted hydrogen water, when the precipitate soon settles again. After two or three such washings by a decantation through a filter, the washing is completed in the filter, always with hot water mixed with sulphureted hydrogen water. It is dried at 100°, separated as completely as possible from the filter, which is incinerated in a porcelain crucible, after moistening the paper with ammonium nitrate. Lastly there is added

to the ash the zinc sulphide and free sulphur, and the whole is ignited in a current of hydrogen according to Rose's process. Or the sulphide may be converted into oxide by roasting.

This method allows of the separation of zinc from the alkaline earthy and alkaline metals, using, for the latter, barium hyposulphate in place of the sodium salt.

As iron, manganese, etc., are not precipitated by sulphureted hydrogen in presence of the hyposulphates, the zinc may be separated from these metals and determined without the previous elimination of iron.—*Comptes Rendus* (vol. cvii., p. 341), *Chem. News.*

[SCIENCE.]

THE ERUPTION OF BANTAISAN, JAPAN.

ON the morning of July 15 occurred a phenomenon of such magnitude, and with results so serious, as to place it among the most remarkable events of volcanic origin of which record exists.

The place of eruption was the mountain of Bantaisan, situated about four miles and a half from Lake Inawashiro, and about a hundred miles directly northwest of Tokio, in latitude 37° 36' north and longitude 140° 6' east. The mountain is the terminal peak of a group of hills rising from an extensive plain, and attains an elevation of about 6,000 feet. Its summit is divided; and the lower or Sho-Bantaisan, with a height of about 5,000 feet, was the actual place of outburst.

The mountain is doubtless of volcanic origin, consisting largely of scoriaceous matter; mostly in a very much disintegrated condition, however. The immediate vicinity has, nevertheless, been the seat of active volcanic disturbance within historical times; though the great earthquake of 1611, and the formation of the lake near Banzai-ya in the location of a mountain which disappeared about 1760, are the most recent phenomena of the region distinctively volcanic in nature.

Bantaisan itself is supposed to have been formed in the year 807, as the result of an eruptive outburst; but there is no actual record of any period of volcanic activity, nor of any definite eruption, though the extinct crater is well defined, and ancient Japanese literature contains numerous allusions to the mountain as emitting flame and smoke.

This dearth of any actual record of eruption, taken together with the appearance of the mountain (which presents from the distance no evidence of former volcanic activity, and is clothed with verdure nearly to the very summit, oak trees growing high up its sides, and only here and there showing projecting eruptive rock), leads to the inevitable conclusion that the mountain must have been free from actual eruptive phenomena for probably a thousand years. Indeed, one ancient writer asserts that Bantaisan ceased its existence as an active volcano with the origin of Lake Inawashiro.

Evidences of slumbering volcanic force remained, however, in the presence, at three different elevations on the mountain sides, of extensive hot springs, the visitors to which were among the chief sufferers from the calamity of July 15.

Premonitory symptoms of an unusual disturbance were first experienced on the 13th, and continued, in the shape of rumbling sounds and slight earthquake shocks, for two days and nights; yet the phenomena were not of such a nature as to cause apprehension, and the final catastrophe found the people of the vicinity wholly unprepared, and took them by surprise.

Definite information as to the exact nature of the occurrence, and accurate details concerning the phenomena actually appearing, are, from the nature of the case, the remoteness and comparative inaccessibility of the locality, and the character of the rural people chiefly affected, not yet procurable. But the facts as at present demonstrated appear to be as follows:

About eight o'clock A.M. the residents of the villages around the base and sides of Bantaisan heard loud rumbling sounds, and experienced severe shocks of earthquake. These phenomena were immediately followed by the falling of showers of ashes, which darkened the sky when not illumined by flashes of dazzling flame, apparently emitted from the earth. Violent earthquakes shook the ground, and the crest of Sho-Bantaisan seemed to be lifted bodily upward, fall again, and totally disappear, in the midst of a violent and deafening explosion.

This phenomenon was followed by showers of red mud, steam, boiling water, and large stones, but no gravel or small stones. Next followed a second shower of ashes mixed with mud, which continued till houses, thatched huts, were buried sometimes to a depth of twenty feet by the ingulfing mass. The phenomena continued in all their severity for about two hours, when the climax seemed to be reached, after which the forces seemed to gradually subside, till about four P.M., when they appeared to have spent their power, and the extent of the catastrophe could be discovered.

All crops for an average radius of five miles from the mountain were destroyed, and great damage was done by the damming of the Okawa River, and consequent inundation of an extensive region. The number of houses totally destroyed was 195, while 63 more were more or less damaged. The total number of deaths is placed at 600, and 476 bodies have been recovered. The number of injured thus far reported is 41, while 1,000 persons are supposed to have been rendered destitute.

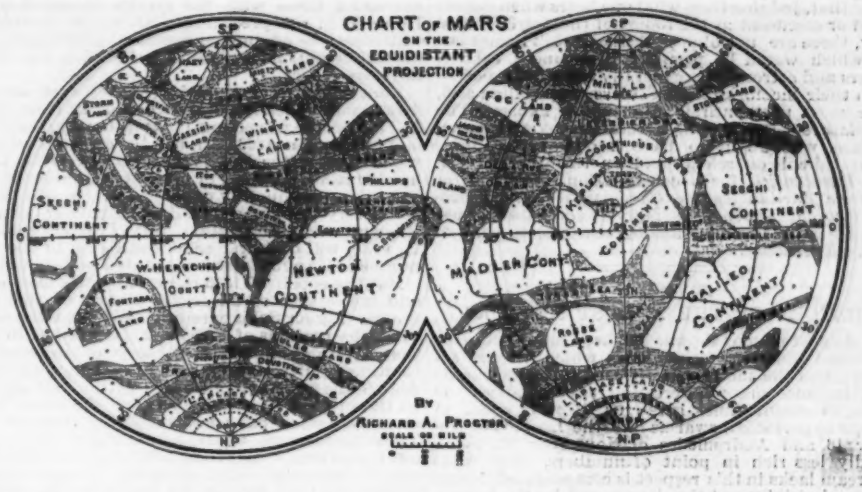
Two craters were opened by the eruption, one of which occupies the site of the former upper spring on Sho-Bantaisan, about two miles from the former summit. The diameter of the crater thus formed is little less than five miles, and the mountain peak above this elevation has wholly disappeared, while one other of the four cones has materially diminished in size. Both craters are at latest accounts, the 26th of July, still in a state of constant though quiet eruption, emitting smoke, steam, and occasionally ashes, the latter having the appearance of disintegrated rock of a dull bluish color.

Though an eruption of Bantaisan has never been considered a probable event, and the recent phenomenon has had no local precedent, the mountain is situated on one of the four lines of volcanic activity known to exist in Japan, embracing a series of several active volcanoes; in the light of which fact, the eruption, with all its attending phenomena and ensuing disaster, cannot be regarded as either exceptional or matter for surprise, though possessing unusual scientific interest, and demanding the fullest human sympathy.—*H. E. Stockbridge.*

MAPS AND VIEWS OF MARS.

By R. A. PROCTOR.

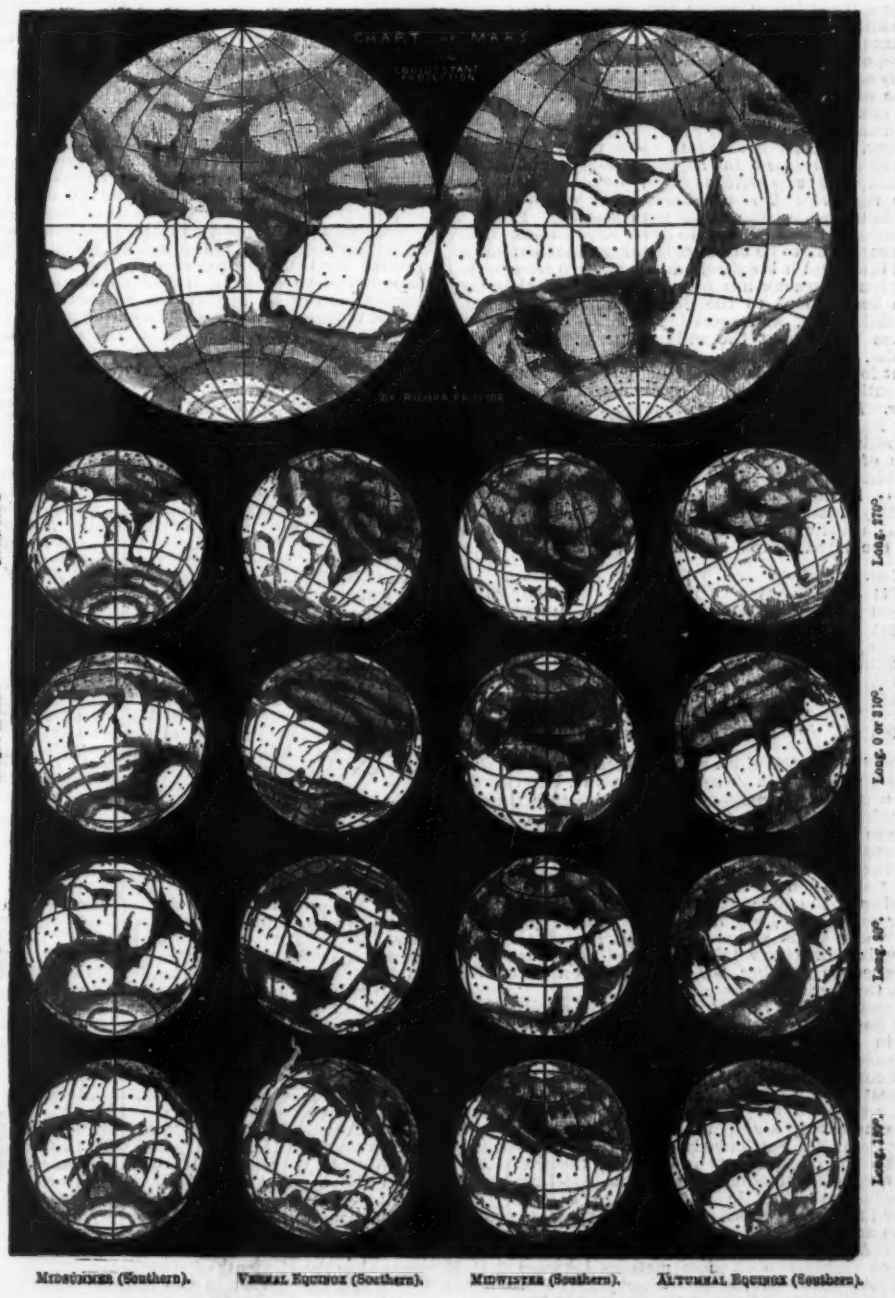
I GIVE the long-promised map of Mars, accompanied by what may be called a picture map, and by a series of projections showing Mars, not as actually seen on any special occasion, but as he would appear if my maps are correct, the air of Mars free from clouds, and observing conditions favorable; only I have included meridians and latitude parallels which have not yet, I presume, been marked by Martian races on the surface of their world, though so to mark them would be child's play compared with the construction of those double canals in which Signor Schiaparelli and M. Perrotin believe.



The maps and projections require no explanation. The history of the researches which have led to the determination of the various features of the planet will be found in part viii. of my "Old and New Astronomy," to be published on November 1.

I may remark, however, with regard to the names which I have used for indicating continents and seas, that while in the main I have followed the nomenclature adopted in my former chart as corrected in that respect by Mr. Green, I have not adopted all his changes, and I have introduced some changes of my own. I never intended my first nomenclature to be definite; indeed, I adopted it merely for convenience of reference in a work of my own on the planet—planned like my "Saturn and its System," but not accepted by publishers as likely to be commercially successful, so that "my poverty, but not my will," forced me to withdraw it from an unappreciative community. Mr. Green was quite right in pointing out that some names were used too often. Mr. Dawes' name, for instance, was given to a continent, an ocean, a sea, an island, a bay, and so forth.

That was all very well for my plan, but not in a chart for general reference. Mr. Green altered and added freely; somewhat too freely, indeed, doing what has always seemed to me undesirable, in crowding in a number of names of living persons (my own included), after a fashion recalling Mr. Birt's preposterous additions to the names of lunar craters. In omitting many of these I have taken the opportunity to substitute unobjectionable names (which may be regarded as only



temporary) for some of those which had been unsatisfactorily named in my former chart. Mist Island, Windy Land, Cloud Land, Cape Steadfast, Gloomy Sea, and the like, are names which, while altogether free from objection in themselves, correspond with the actual appearance of the features named.

Of Signor Schiaparelli's classical nomenclature I can only say that, judging from what one hears when papers are read or discussed at the rooms of the Astronomical Society, there are not nine of Schiaparelli's names out of ten which would be properly pronounced, even if observers and astronomers generally could be expected to fix in their memories a series of sesquipedalian and, for the most part, entirely unmeaning names. The nomenclature belongs to the affectations by which men of science, who ought to have known better, have brought ridicule on science and on themselves. *Machina Pneumatica* for a constellation, *Margaritifer Sinus* for a Martian feature, *Chromosphere* and *Leucosphere* for solar appendages, and all such absurdities, should have no existence among sensible students of science.—*Knowledge.*

[Nature.]

A HISTORY OF THE AUGUST METEORS.

The August meteor shower has been more frequently observed than any other with which we are acquainted, and the modern history of this remarkable system includes many interesting circumstances. It has not, in recent times, given us displays equal in grandeur to periodical swarms like the Leonids of November 13 and Andromedes of November 27, being decidedly less rich in point of numbers. But what this stream lacks in this respect is compensated for by the *annual* visibility of the shower and by the intense brilliancy of some of its individual members. Every year the August meteors present a conspicuous appearance on the night following St. Lawrence's day, and fire balls of excessive luster are now and then interspersed with the smallest perceptible shooting stars of the system. The Leonids and Andromedes, which have rendered the month of November so famous in meteoric annals, can only reappear abundantly at intervals of thirty-three and (probably) thirteen years, whereas the Perseids of August are unfailing in their regular apparitions as the epoch comes round each year. On the night of the 10th the most casual observer will not fail to notice the surprising frequency of shooting stars, and must remark their occasional brilliancy and the persistency of the phosphorescent after-glows which they generate during their rapid flights among the fixed stars.

The early history of the August meteors is vague and meager in the extreme. Ancient writings are significantly mute as to the scientific aspect of meteor showers. Doubtless in olden times these phenomena were equally as plentiful as at present, but amid the ignorance and superstition which prevailed, they were little regarded. The prominent part which meteors play in the solar system was not suspected. Hence no importance was attached to their appearance. They were supposed to be mere exhalations uncontrolled by fixed laws, and it is entirely due to modern science that their true character has been revealed, and that they have been raised to the dignity of bodies having a celestial origin, and probably also an extensive influence throughout the wide range of astronomical physics.

But former records, if void of particulars possessing a scientific utility, are yet often useful in supplying *dates*. Many old references to meteor showers, though very imperfect in description, are, by the accordance of epoch, justly assumed to have been early exhibitions of the very same systems as those which have furnished some of the most imposing displays of recent years. In the catalogue of 315 meteoric showers compiled by Quetelet, a considerable proportion are probably identical with the August Perseids, and below we give the dates, up to a century ago, of these:

Year.	Date.	Year.	Date.
811	July 25	926	July 27–30
830	" 25–30	933	" 25–30
834	" 26–28	1243	Aug. 2
880	" 26	1451	" 7
833	" 27	1709	" 8
835	" 26	1779	" 9 and 10
841	" 25–30	1781	" 8
924	" 27–30	1784	" 6
925	" 27–30	1789	" 10

The dates in the ninth and tenth centuries are somewhat different from those in later years, but this does not negative the assumed relation, because they are brought nearly into agreement when the change of style in 1752 is allowed for. This proves the showers to have really occurred at a period early in August, according to present reckoning. There may also be a slight alteration in the epoch of the swarm due to a shifting of the node, which, in its cumulative amount after many ages, might reach a considerable value. For the reasons assigned, the celebrated shower of Leonids, which now takes place on November 13, was observed in October, 902, and again on October 19, 1202, October 23, 1366, etc.

Muschenbroek, in 1762, announced the general fact that he had observed shooting stars to be more plentiful in August than in any other month of the year. Further toward the close of the century this was in part confirmed by the apparition of many meteors on August 8 and 9. In 1806 and 1812 Dr. Forster, of Clapton, recorded in his "Calendar" that these phenomena were unusually abundant on August 10, and in the latter year he particularly noted the extraordinary length and phosphorescent aspect of the trains left in their wake. Subsequently the same epoch was amply corroborated; and in 1835 Quetelet definitely mentioned the 9th and 10th of August as the date of maximum annual display.

On August 9, 1837, M. Wartman, of Geneva, observed eighty-two of these meteors between 9 P. M. and midnight. In the following year, on August 10, observations were made at Geneva and at Planchettes, a village sixty-two miles northeast of Geneva, with the view of determining the heights and velocities of the meteors. A discussion of the results showed that the average elevation above the ground was 550 miles, and the velocity 220 miles, but these figures are now known to have been enormously in excess of the true values.

From twenty meteors observed in August, 1863, Prof. A. S. Herschel determined the mean height as 81·6 miles at first appearance and 57·7 miles at disappearance, and the velocity was found to be 34·4 miles per second. From twenty-seven meteors similarly observed in Italy between August 5 and 10, 1864, Secchi derived limiting heights of 76·6 and 49·7 miles; and, averaging these with the results obtained by Prof. Herschel in the preceding year, we get 78 to 54 miles, which may be adopted as representative values, for the normal heights not only of the Perseids, but of shooting stars generally.

Heis, Schmidt, Greg, and Herschel were among the first to methodically observe the August meteor shower and determine its radiant point in the northern region of Perseus. In 1863, August 10, an unusual display was witnessed, for on this occasion the stream seems to have attained a degree of intensity not recorded either before or subsequently to that year. In 1871 there was also a very pronounced and abundant appearance of these meteors. In *Nature*, vol. xx., p. 457 (September 11, 1879), will be found some details as to the relative number of August meteors counted in different years.

But the epoch of 1866 is, perhaps, the most eventful and interesting of all in the history of this notable group. Signor Schiaparelli, of Milan, in the course of some observations of the Perseids, was led to take up the investigation of the theory of shooting stars. Cautiously sifting the available materials, and forming deductions from facts indicated by the best authorities on the subject, he was induced to the belief that meteors were small particles composing cosmical clouds. These clouds were, by the action of gravitation, spread out into streams, and their orbits formed, like those of comets, elongated conic sections. From a method explained by Prof. Erman, he computed the orbital elements of the August meteors and of certain other streams, and, comparing them with the orbits of comets, discovered two remarkable coincidences between the system of Perseids and Comet III., 1862, and the Leonids and Comet I., 1866. In each case the paths of the meteor group and comet were identical, and every circumstance favored the inference that the two phenomena were physically identical, the meteors forming the dispersed material of the comet. The period of the Leonids (November 13), viz., 33¼ years, agreed precisely with that of their supposed parent comet. The period of the August display, however, remained doubtful, the ellipse being more elongated; but Schiaparelli adopted a cycle of rather more than one hundred years, as best satisfying the observations, though the exact period is still doubtful.

Computation showed that the radiant point of meteoric particles following the track of Comet III., 1862, would be seen on August 10, at R. A. 43°, Decl. 57½° N. In 1863, on August 10, Prof. Herschel had observed the meteors, and fixed their radiant at R. A. 44°, Decl. 56° N., a wonderfully close agreement, considering the difficulties attached to such observations. This, and other coincidences of orbit, removed all doubts as to the affinity of meteors and comets; and later evidence, especially that afforded by Biela's comet and the splendid meteor showers of November 27, 1872 and 1885, has afforded convincing proofs as to the validity of the theory enunciated by the Italian astronomer.

Some interesting features in connection with the August meteors still, however, awaited further investigation. The visible duration of the shower was unknown. The radiant was thought to be diffused over a region extending from Perseus to Cassiopœia. Mr. R. P. Greg, in his "Table of Radiants" (*Monthly Notices*, 1872, p. 353), places it over the area from R. A. 50°–25°, Decl. 44° N., to R. A. 50°–65°, Decl. 56° N.; and Serpieri gave R. A. 50°–30°, Decl. 49°–64°. Mr. J. E. Clark, in 1874, undertook the projection of the tracks of about 2,000 Perseids described in the "Luminous Meteor Reports" of the British Association, with the object of detecting motion in the radiant center on successive days or hours of the night, but without definite success, though the observations suggested a progressive motion on succeeding nights similar to that noticed by Prof. Twining in 1859. In 1877 the shower was watched by the writer at Bristol on several nights, and the radiant was distinctly seen to take up a fresh position with every change of date. It moved from R. A. 40°, Decl. 56°, on August 5, to R. A. 60°, Decl. 59° N., on August 16. The fact was first announced in *Nature* for August 30, 1877 (vol. xvi., p. 362), and many observations in subsequent years at the same station have fully confirmed the shifting of the radiant, and indicated the long duration of the shower. In the following table will be seen the position of the radiant at intervals of five days:

July 8.....	3° + 49°	August 2.....	36° + 55°
13.....	11° + 50°	7.....	42° + 57°
19.....	19° + 51°	12.....	50° + 57°
23.....	25° + 52°	17.....	60° + 58°
28.....	31° + 54°		

The whole duration extends, very probably, over the forty-five days from July 8 to August 22, and in the interval the radiant moves from 3° + 49° to 77° + 57°. This cluster is evidently one of enormous width, and has doubtless undergone distortion by the effect of planetary perturbation. Some interesting facts in connection with this and other cometary meteor systems will be found in the *Sidereal Messenger* for April and May, 1886. With regard to the August meteor shower, it appears that a certain change in the position of the radiant ought theoretically to occur every night, but the observed displacement does not well accord with computation. On July 26 the Perseid radiant is about 4°, and on August 19 about 9°, from the radiant of its derivative comet (III., 1862); and these differences are doubtless to be referred to the disturbances exercised upon the original stream by the attraction of the earth. At every return of the group a vast number of the particles must obviously pass very near to us without being dissipated by the action of our atmosphere, and the paths of these will be affected to an extent that must alter the elements of their orbits.

Though the period of the August meteors has not yet been precisely ascertained, there is no question that the shower exhibits fluctuations from year to year as regards intensity, and that, like the two great systems of November, a certain cycle regulates its most brilliant displays. Future observations will determine the precise form of the orbit. The return of Comet III., 1862, or a recurrence of the very rich shower of August, 1863, will decide the matter, but as the orbit is one of considerable eccentricity, several generations may yet elapse before the period is accurately ascertained. It is certain that many of the supposed variations in the perennial intensity of the display are more apparent than real, because the successive returns are witnessed under different conditions. Cloudy or misty weather sometimes interrupts observation; moonlight offers another impediment; occasionally, also, the maximum is attained in daylight, and passes unheeded. The same observer is not always enabled to maintain an outlook from positions equally favorable; and there are other circumstances which, with those mentioned, prove the difficulty of securing a series of observations fairly comparable with each other. Usually about forty or fifty meteors per hour may be counted by one observer before midnight on August 10, but in the early morning hours of August 11 as many as eighty or ninety, perhaps more, will be seen, as the radiant is then higher and better placed for the visible distribution of its meteors.

"The August meteors," though a general term capable of being applied to any showers observed in the month of August, is commonly employed in special reference to the Perseids of August 10. There are large numbers of minor displays visible in the same month, the radiant points of which are scattered profusely over the firmament. There are certainly more than one hundred showers in contemporaneous action with the Perseids, and many of these are now pretty well known, a mass of observations having accumulated for this particular epoch.

In the present year the great August shower has not been especially brilliant, though many of its meteors have appeared under their customary aspect. At Bristol, on August 2, 42 shooting stars were counted during the 2½ hours between 10 h. 50 m. and 13 h. 21 m., and 14 of these were Perseids from a center at 35° + 54°. On August 5, 31 meteors were seen in a similar interval, including 11 Perseids. On August 8, in 3 hours, from 10 h. to 13 h., 36 meteors were observed, and among these were 20 Perseids. The radiant, both on the 2d and 5th, seemed to be at 42° + 57°. The few subsequent nights were overcast, but on the 13th a clear sky permitted watching, and during the 3½ hours from 10 h. to 13 h. 30 m. 49 meteors were seen, of which 13 were Perseids from a radiant at 52° + 57°. On August 14, between 10 h. and 13 h., 25 meteors were noted, but there were only two Perseids among them.

On August 8, Mr. Booth, at Leeds, watched the eastern sky for 4¼ hours, and saw 45 meteors, including 25 Perseids. The radiant was at about 42° + 57½°, and it will be observed that the proportion of Perseids to the total number of meteors observed was the same as noted at Bristol on that date. On August 13, Mr. Booth recorded 13 Perseids from a radiant at 51½° + 56°, thus confirming the displacement observed at Bristol.

On August 10, Mr. G. T. Davis, of Theale, near Reading, reports the sky was clear and many meteors were visible between 9:30 and 11 P. M., the majority being Perseids. The same observer recorded a number of paths on August 5 and 8, and a comparison of his results with similar observations at Bristol shows that 7 meteors were doubly observed at the two stations. Their heights, etc., were computed by the writer as follows:

Date. 1888.	Hour. G. M. T.	Mag.	Height at appearance.	Height at disappearance.	Length of real path.	Radiant point.	Inclination to horizon.
Aug.	h. m.		Miles.	Miles.	Miles.	Deg.	Deg.
5....	10 19	1–3	69	50	37	50 + 55	27½
5....	10 30	3–4	69	48	38	39 + 57	34
5....	10 42	3–4	68	48	24	43 + 51	29
8 ...	10 6	3–5	70	59	28	66 + 56	23
8....	10 10	3–4	65	52	38	319 — 13	20
8....	10 21	3–3	43	28	26	40 + 60	35½
8....	10 28	4–4	68	48	24	42 + 57	33½

The close agreement in the heights of these meteors (except in the case of No. 6 in the list, which was much nearer the earth's surface than usual) will be noticed. They were, with the exception of No. 6, which belonged to a radiant in Aquarius, all members of the August meteor system, though in several cases, notably that of No. 4, the path, as observed at Reading, was not exactly conformable to the radiant point of this shower.

The recent display has furnished us with a splendid fire ball. It appeared on August 13 at 11 h. 38 m., and was seen by Mr. Booth at Leeds, by Mr. Monck at Dublin, by the writer at Bristol, and by several observers at Birmingham and other places. When near its disappearance the fire ball acquired such brilliancy that it lit up the firmament like a vivid flash of lightning, and in the latter portion of its path there remained a comet-like streak, which at Leeds and Birmingham continued visible for three minutes. The descriptions of this exceptionally fine meteor are in good agreement. It traversed a course above Yorkshire at normal heights; its brilliant streak had a mean elevation of 53 miles and length of 18 miles. No detonation appears to have been heard. W. F. Denning.

ANCIENT ROMAN BATHS AT BATH, ENGLAND.

One of the most ancient, and perhaps the most beautiful, of the cities in the West of England—attractive in name and fame, agreeable in situation, handsomely built, with an aspect of polite elegance in keeping with its old-fashioned celebrity, and with an air of urban retirement peculiarly its own—Bath was chosen for this year's congress of the British Association of Science.

The list of people who visited the city of Bath begins with the very earliest of "British associations;" for King Bladud, grandson of the King Lud who built Ludgate, in London, a descendant of the Trojan hero Brutus, who gave his name to Britain, was cured of leprosy by the Bath medicinal waters. He discovered their efficacy by having infected a herd of swine with his disease, and observing that they got rid of it by wallowing in a local pool. If a skeptical generation will not believe Geoffrey of Monmouth, who ought to know better than we can, as he lived much nearer the time, which was 860 B. C., let them give credit to the Bath townsfolk of A. D. 1699. A statue

THE ROMAN BATHS OF AQUÆ SOLIS, AT BATH.

CIRCULAR BATH, RECENTLY DISCOVERED.

ROMAN BATH, 110 FT. LONG, 68 FT. WIDE, WITH REMAINS OF VAULTED HALL.

of Bladud was then set up. Geoffrey of Monmouth says that Bladud, a philosopher and necromancer, the father of King Leir or Lear, was the founder of Bath. The Romans, about the year A. D. 54, occupied the town, which they called Aquæ Solis, "The Waters of the Sun."

The situation of Bath is not inferior in natural beauty to that of Florence. The valley is similarly an amphitheater of verdant hills, rising on the east side to the height of 600 ft., at Claverton; on the north, Lansdowne Hill, to 818 ft.; and on the west, at Bathwick, to 400 ft.; while the city, instead of lying wholly at the bottom, ascends these hills, forming terraces, squares, and crescents, one above another, of fair stone houses, intermixed with gardens and trees; the Avon, which is as little beautiful as the Arno, flows in a deep hollow beneath them. Such is the present aspect of Bath.

The Roman city of Aquæ Solis was much smaller, covering mainly that part of the site of modern Bath, to the west and south, which is now represented by Westgate street and Stall street. It comprised a great permanent camp for two legions of Roman soldiers, a quadrangle with a grand street, 100 ft. wide, running through the center; and the grand Basilica, the Temple of Diana, and the Temple of Minerva, stood nearly where the Abbey, with its churchyard, and the Pump-room, now stand. Architectural remnants, fragments of fluted columns, sculptured capitals and cornices, prove the magnificence of those Roman edifices. To the southwest of the Basilica, on the other side of the present Abbey street, were discovered, first in 1755, portions of the Roman baths, the further discovery of which took place in 1871, and then excited much antiquarian comment. There are sundry hot springs in the soil under this quarter of the city, and the Romans built their baths directly over the largest, to economize its natural heat.

The visitor will find himself amply compensated for an inspection of the Roman baths, which, within the last few years, have been exposed by the corporation —perhaps the most remarkable relic extant of the Roman occupation.

The Roman bath, shown in one of our illustrations, is 81 ft. long and 38 ft. wide, which was in the center of a hall, 110 ft. long and 68 ft. 6 in. wide, formerly roofed with a vault supported by pilasters and arches, divided into three aisles, the middle aisle covering the bath. The pedestals and lower part of several of the massive pilasters, with the steps going down to the water, appear in the illustration; behind them, in the side aisles, which were decorated with sculpture, was a promenade gallery. The floor of this hall is 20 ft. below the level of the neighboring modern street. Another spacious apartment contained two sudatories, or sweating rooms, with a fireplace between them and flues to heat them. The circular bath, recently discovered, appears to have been once lined with lead.

In the fifth century of the Christian era, when the Romans had departed, there was a period of confusion among the half-civilized natives, with whom some Belgian colonists were intermixed. Aquæ Solis, the stately and luxurious Roman fashionable watering place, fell into ruin. The Saxon invaders of Wessex, in 520, besieged this town, but were defeated on "Mons Badonicus" by the renowned King Arthur. In 577, King Ceaulin, ruler of Wessex, aided by Cuthwin, achieved the victory of Deorham or Dyrham, eight miles from Bath, killing three British chieftains, and successfully fought the more decisive battle, supposed to have been at Badbury, near Blandford, in Dorsetshire. The three important cities, Bath, Cirencester, and Gloucester, then fell into the hands of the Saxons or "English;" and the Celtic population were driven westward to Exmoor, and into the parts of Devonshire beyond the Exe. When the Saxons became Christians, a monastery was erected at Bath, in 676, by King Osric of Hwicca; a century later, King Offa, of Mercia, who had annexed much of Wessex to his dominion, built a cathedral here, in which King Edgar was crowned by St. Dunstan, Archbishop of Canterbury, in 973. Bath was further exalted by King Athelstan, who established a royal mint in this city. Under the Normans, though it suffered a cruel punishment from William Rufus for taking part with his brother Robert, its prosperity was advanced by the liberality of John de Villula, of Tours, Bishop of Bath and Wells, who constructed the Abbey Baths, committing their charge to the abbot and prior of the Benedictine monastery, for the public benefit. Another bishop founded the Lepers' Hospital, providing it with the lepers' bath, which continued for centuries to be appropriated to the exclusive use of that unfortunate class of patients. —*Illustrated London News.*

RESPIRATION.

AT a recent meeting of the Physiological Society, Berlin, Prof. Zuntz described a simplified method of measuring the gaseous interchange during respiration, intended to make it possible to introduce such measurements into the limits of clinical observations to the same extent that urinary analysis is now carried out. In this method breathing is carried on, the nose being closed, through a mouth piece which is connected by very mobile valves with gasometers, which thus measure the volume of the inspired as well as of the expired air. Samples of the expired air can be collected at any desired intervals of time and the amount of O and CO_2 which they contain determined by Hempel's method. The burette into which the gas is drawn off, by means of an aspirating apparatus connected with the gas meter, is connected by a gutta-percha pipe with a vertical tube which is partly filled with water: the latter not only permits of the measurement, at atmospheric pressure, of the volume of air drawn off, but also provides a means of forcing it out of the burette into a pipette filled with a solution of caustic potash, in which the absorption of the CO_2 speedily takes place. By lowering the tube the gas is allowed to pass into the burette again, and the reduction in its volume gives the amount of CO_2 in the expired air. After this the gas is forced into a pipette which contains lumps of phosphorus, which absorb all the oxygen it contains in five or six minutes. On passing the gas again back into the burette, the further diminution in its volume gives the amount of O in the expired air. A new sample can now be taken, and thus the expired air may be tested as often as may be desired for its contents of O and CO_2. Dr. Loewy has carried out some experiments with the above apparatus on five intelligent persons in order to determine the influence of digesting activity on the respiratory interchange. The respiratory interchange of the patients was determined in the morning while fasting and in a perfectly quiescent condition; as soon as this was found to be constant they received doses of 5, 10 or 15 grains of Glaubersalt, and as soon as the action of the salt had manifested itself painfully, and increased peristaltic action had set in, the respiratory interchange was again determined up to the time of defæcation. In all cases the gaseous interchange was increased, more oxygen being used up and more carbonic acid given out, the increase being between 7 and 35 per cent. of the normal. The several persons behaved very differently in this respect, and the same person showed marked differences in the increase of respiratory interchange at different times, after equal doses of the salt. As a rule the increase was proportional to the amount of discomfort experienced by the patient in the lower parts of the body. Dr. Loewy is inclined to attribute the increased oxidational interchange to the greater activity of the unstriated muscles of the alimentary canal; the increased activity of its mucous membrane, resulting from the presence of the purgative, appeared to have no influence.

IF the mind is continually concentrated upon an especial subject, it soon becomes fatigued and weakened, as the muscles are tired and exhausted by one prolonged physical effort. Change is essential alike to health and happiness. The intellectual labors should be diversified, and the powers refreshed and renewed by relaxation, indulgence in amusing recreation, and habitual muscular exertion.—*Journal of Health.*

A New Catalogue of Valuable Papers

Contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address. MUNN & CO., 361 Broadway, New York.

THE SCIENTIFIC AMERICAN

Architects and Builders Edition.

$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture**, richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

MUNN & CO., Publishers,
361 Broadway, New York.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilation, and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

Building Plans and Specifications.

In connection with the publication of the BUILDING EDITION of the SCIENTIFIC AMERICAN, Messrs. Munn & Co. furnish plans and specifications for buildings of every kind, including Churches, Schools, Stores, Dwellings, Carriage Houses, Barns, etc.

In this work they are assisted by able and experienced architects. Full plans, details, and specifications for the various buildings illustrated in this paper can be supplied.

Those who contemplate building, or who wish to alter, improve, extend, or add to existing buildings, whether wings, porches, bay windows, or attic rooms, are invited to communicate with the undersigned. Our work extends to all parts of the country. Estimates, plans, and drawings promptly prepared. Terms moderate. Address

MUNN & CO., 361 BROADWAY, NEW YORK.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ASTRONOMY.—History of the August Meteors.—By W. F. DENNING.—Ancient records of the star showers of August, the results of the 1888 observations, interesting tabulation of records of the past and of to-day. 10660
Maps and Views of Mars.—Equidistant chart of Mars, with various views of the planet, the question of nomenclature to be applied to its geographical features.—19 illustrations 10660

II. CHEMISTRY.—Apparatus for Fractional Distillation in Vacuum.—By SPENCER B NEWBURY.—A simple and effective apparatus for this purpose.—1 illustration 10664
A Process for Separating and Determining Zinc.—By J. RIBAN. A modification in the precipitation of zinc as sulphide, giving an easily managed precipitate. 10664
Modification of Harcourt's Color Test.—By WILLIAM G. HICKS.—2 illustrations 10660
The Specific Gravity of Gas.—A balance for continuously indicating the specific gravity of gas.—3 illustrations 10660

III. CIVIL ENGINEERING.—The Forth Bridge.—By F. E. COOPER.—A very full and authoritative account of the progress of work on the great cantilever bridge, followed by a discussion in which American and English representative engineers participated.—4 illustrations 10660

IV. ELECTRICITY.—Dynamo Current Interferences with Telephone Systems and Means of Relief.—By C. E. MCCLURE.—A plea for the ill effects of leakage rather than of induction as the disturbing element in telephone lines, a suggestive paper 10666
Method of Depositing the Heavy Metals.—Prof. S. P. THOMPSON'S improvements in the electric deposition of metals of the platinum group, an important advance in electro-metallurgy 10667
Specification of Wiring.—A proposed electrical installation, with details of wiring, of value to all electrical engineers 10668

V. FINE ARTS.—The Soldier's Return.—By ROBERT DIEZ.—A bronze group forming part of a monument at Braunschweig, the soldier greeting his parents.—1 illustration 10667

VI. MISCELLANEOUS.—Mr. Flinders Petrie's Discoveries in Egypt. 10668
Ancient Roman Baths at Bath, England.—The remains of the palatial Roman bathing places at Bath.—2 illustrations 10669
The Eruption of Bantaisan, Japan.—The eruption of July 15, 1888; one of the most disastrous volcanic disturbances in the world's history 10669

VII. NAVAL ENGINEERING.—Improved Elevator Ferry Boat.—A ferry boat with elevating deck for dock and ship service at varying elevations.—4 illustrations 10664
The Steam Launch Deva.—A steam launch fitted with Mr. Arthur Rigg's new type of revolving engine.—4 illustrations 10664

VIII. PHOTOGRAPHY.—Intensification, Weak and Strong.—Eight intensification processes, of as many degrees of strength, arranged systematically 10662

IX. PHYSIOLOGY.—Note on Recreation 10660
Respiration.—Description of Prof. Zuntz's method of analyzing the products of respiration, and results of experiments on five human subjects 10662

X. TECHNOLOGY.—British and American Cottons in China.—The relative quantities supplied from each source, with tabular statement of the imports of six years 10660
Improvement in the Manufacture of Phosphorus.—Nicolle's improved process of making phosphorus, by precipitating it as phosphate of mercury, with subsequent distillatory treatment 10660
Indigo Culture in China.—How indigo is cultivated in China, and how the dye is extracted from it 10660
Pulp Manufacture from Wood in Germany.—A great German industry, the canceling of the patent, and suggestions for the establishment of the process in Canada 10660
The Value of Oil as Fuel.—Several views of engineers as to the economy of petroleum oil as a fuel 10660

Useful Engineering Books

Manufacturers, Agriculturists, Chemists, Engineers, Mechanics, Builders, men of leisure, and professional men, of all classes, need good books in the line of their respective callings. Our post office department permits the transmission of books through the mails at very small cost. A comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation, at the office of this paper. Subjects classified with names of author. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address,

MUNN & CO., 361 Broadway, New York.

PATENTS.

In connection with the **Scientific American**, Messrs. MUNN & Co. are solicitors of American and Foreign Patents, have had 42 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained, by writing to MUNN & Co.

We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs, and how procured. Address

MUNN & CO.,
361 Broadway, New York.

Branch Office, 622 and 624 F St., Washington, D. C.